APRIL 1958

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 50 • NO. 4

Big D—site of AWWA's 78th and biggest Annual Conference Apr. 20–25

In this issue:

All internal parts, including the drain valve seat, are drawn through the top of the hydrant without disturbing the standpipe.

We can show you—right in your office—why Mathews dry-head construction is so important

No community can afford to take chances with its hydrants. They *have* to work—not just when they're new, but in every single emergency during the course of a long, long life. That's why the dry-head construction of the Mathews Flange Barrel Hydrant is so significant. It keeps sand and ice and sediment from accumulating and interfering with its instantaneous operation, a feature that can be highly important.

We can actually show you what we mean without even asking you to get up out of your chair. We'll bring our scale model to your office and disassemble it so that you can see its inner workings. Why not write us today and ask for one of our representatives to show you these important features.

R. D. WOOD COMPANY

Public Ledger Building, Philadelphia 5, Pa.

Manufacturers of Mathews Hydrants and "Sand-Spun" Pipe (centrifugally cast in sand molds)

Journal

AMERICAN WATER WORKS ASSOCIATION | **April 1958**

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Contents

Departments

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Directory of Professional Services—pp. *74-80 P&R*

"Transite's installation recent increases

Says Philip J. Holton, Jr.
Chief Engineer
Water Supply Board
Providence, R. I.

"Our records show that labor and material costs have increased 100% since 1946. Yet, in this same period of time, our installation costs have increased only 21%. The ease of handling and speed with which contractors can lay Transite Pipe enable us to take full advantage of modern equipment and methods. In this way, Transite has played a prominent part in helping us offset increased costs."

Transite Pressure Pipe helps you cut system costs 3 ways: in design—installation—operation!

Today, in every part of the nation, municipal and consulting engineers choose Transite® Pressure Pipe. Ask why, and you find that economy is always among the Transite advantages they consider most important. For no pipe does so much to help keep your costs low in these three different ways:

1. Design. Transite lets you plan a system for maximum efficiency. For its high carrying capacity (flow coefficient, C=140) often lets you specify pipe of smaller diameter. And because Transite's smooth interior remains smooth, you never need to make costly allowances for future reduction in carrying capacity.

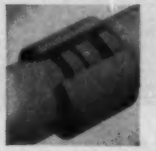
2. Installation. Transite's installation speed cuts time and labor costs substantially. Light in weight for so durable a pipe, it handles easily above and below ground. And its Ring-Tite Coupling assembles quickly, surely . . . giving you a tight

savings have helped us absorb in labor and material costs..."

Crews of Fanning and Doorley Construction Co. installing 8" line in Providence, R. I.

seal at every coupling in the system.

3. Operation. Here's where Transite really saves! For its maintained carrying capacity keeps pumping costs low year after year. Its strength, durability and corrosion resistance cut maintenance to a minimum, provide years of trouble-free service.



Transite's Ring-Tite® Coupling cut away to show how rubber rings are compressed and locked in place to form a tight yet flexible joint.

We'll be pleased to send you booklet TR-160A.
Write Johns-Manville, JA Box 14, N. Y. 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

AWWA ANNUAL CONFERENCE

Dallas, Tex. **Apr. 20–25, 1958**

Official reservation forms have been mailed to all members and are returnable to AWWA.

Coming Meetings

AWWA SECTIONS

Spring Meetings

Apr. 16–18—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, Rupert C. Ott Jr., Neptune Meter Co., 2818—21st St., Columbus.

May 15–17—Pacific Northwest Section, at Davenport Hotel, Spokane, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., 306 City Hall, Spokane, Wash.

May 15–17—Arizona Section, at El Conquistador Hotel, Tucson. Secretary, Stanford I. Roth, Supervisor of Water Collections, Div. of Water & Sewers, Phoenix.

Jun. 1–4—Canadian Section, at Royal York Hotel, Toronto, Ont. Secretary, A. E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Commission, Parliament Buildings, Toronto.

Jun. 25–27—Pennsylvania Section, at Hotel Lawrence, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Fall Meetings

Sep. 8–10—Michigan Sec., Grand Rapids.

Sep. 10–12—New York Sec., Lake Placid.

Sep. 15–17—Rocky Mountain Sec., Denver, Colo.

Sep. 17–19—Ohio Sec., Cleveland.

Sep. 17–19—Wisconsin Sec., Wausau.

Sep. 22–24—Kentucky-Tennessee Sec., Memphis, Tenn.

Sep. 24–26—North Central Sec., Duluth, Minn.

Sep. 28–30—Missouri Sec., Jefferson City.

Sep. 28–Oct. 1—Alabama-Mississippi Sec., Biloxi, Miss.

Oct. 15–17—Iowa Sec., Des Moines.

Oct. 19–22—Florida Sec., North Miami Beach.

Oct. 23–24—West Virginia Sec., Charleston.

Oct. 23–25—New Jersey Sec., Atlantic City.

Oct. 28–31—California Sec., Los Angeles.

Oct. 29–31—Chesapeake Sec., Wilmington, Del.

Nov. 5–7—Virginia Sec., Richmond.

Nov. 10–12—North Carolina Sec., Greensboro.

(*Continued on page 10*)

The "SALUTE" ad reproduced on the opposite page is one of a Byron Jackson series scheduled in newspapers throughout the United States.

IMPORTANT: A full color wall size reprint (20" x 17") of this original painting by Herbert Fillmore is available without obligation to all persons concerned with water planning and supply. Write to W. S. Thomas, Byron Jackson Pumps, Inc., Box 70C, Lawrenceburg, Indiana or ask your nearby BJ Pump office.

Coming Meetings

(*Continued from page 8*)

OTHER ORGANIZATIONS

Apr. 15–16—Lead Industries Assn. Annual Meeting, at Chase-Park Plaza Hotels, St. Louis, Mo.

Apr. 18—Conference on Control, Instrumentation & Automation in Water Supply Field, sponsored by Missouri Section (AWWA) and Missouri Univ., at Student Union Bldg., Missouri Univ. For program and registration information, write: Warren A. Kramer, State Office Bldg., Jefferson City, Mo.

May 5–7—Purdue Univ. Industrial Waste Conference, Purdue Memorial Union Bldg., Lafayette, Ind.

May 12–14—Analysis Instrumentation Div., Instrument Society of America, Shamrock Hilton Hotel, Houston, Tex. For registration information write: H. S. Kindler, ISA Director of Technical Programs, 313—6th Ave., Pittsburgh, Pa.

May 18–24—Congress of Inter-American Assn. of Sanitary Engineering (AIDIS), San Juan, P.R. For details, write: Gen. Secy. Enrique Ortega, Apdo. Postal 218, San Juan, P.R.

May 19–23—Short Course on Safety Management Techniques, sponsored by National Safety Council, Chicago, Ill. Write: Director of Industrial Training, National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

May 24–31—International Water Supply Congress, Brussels, Belgium (in connection with World's Fair). For information, write: Belgian Organizing Committee, 10 Square Ambiorix, Brussels 4, Belgium.

May 30–Jun. 1—European Organization for Research on Fluorine and Dental Caries Prevention, Brussels, Belgium (in connection with World's Fair). For information write: Dr. M. Joachim, Chairman, Organizing Committee of ORCA Congress, 67 Rue de Treves, Brussels, Belgium.

Jun. 10–12—Appalachian Underground Corrosion Short Course, School of Mines, West Virginia Univ., Morgantown, W.Va.

Jun. 22–27—American Society for Testing Materials, Hotel Statler, Boston, Mass.

Sep. 1–13—2nd International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland.

Oct. 5–9—Federation of Sewage & Industrial Wastes Assns., Detroit, Mich.

Oct. 13–17—American Society of Civil Engineers, New York, N.Y.

SALUTE

TO THE MEN WHO HOLD YOUR WATER FUTURE IN THEIR HANDS

The BJ Submersible shown here combines motor and pump in one powerful package that quietly works out of sight and sound. It is one of the modern answers to water supply pumping.

BJ

AT THE TURN of a tap... the indispensable fluid called water flows to keep our homes and community healthy and clean... our farms and industry prosperous and productive.

But today's life-giving water is not the instant servant it seems. Your local officials and water department—and the consulting engineers and pump dealers who work with them—have planned and built years in advance to put this water "on tap." *These men hold our water future in their hands.* Help and support them in this vital work.

BYRON JACKSON PUMPS

INCORPORATED

A Subsidiary of Borg-Warner Corporation · P.O. Box 70, Lawrenceburg, Indiana

HAGAN COAGULANT AIDS NOS. 7, 11, 18 SAFE FOR DRINKING WATERS

Capacities, Filter Runs Increased, Costs Reduced

In these days of rapidly expanding communities many municipal water plants find themselves short of capacity. Increased flow rates often result in floc carry-over onto filters.

The desire to supply better water has led many municipalities to partially soften water with lime, or lime and soda ash, in existing equipment. The fine precipitate formed very often settles slowly and filter incrustation occurs.

Hagan Coagulant Aids 7, 11 or 18 have been used to great advantage in overcoming these difficulties. Due to their binding power, Hagan Aids produce larger, heavier flocs than coagulants alone. The weighting action of these aids promotes more rapid settling.

NEW BULLETIN AVAILABLE

A new bulletin describing Hagan Coagulant Aids Nos. 7, 11 and 18, giving typical case histories of Hagan Coagulant Aid uses, is available on request.

FIRST COAGULANT AID USER

Over two years ago a Western Pennsylvania municipal water plant became interested in Hagan Coagulant Aids when trouble was experienced with floc formation. The plant was clarifying 15 to 20 million gallons of river water in conventional sedimentation basins, using lime and aluminum sulfate.

Experiments were made with activated silica and Hagan Coagulant Aids. Operating experience showed that both activated silica and Hagan Coagulant Aid No. 18 greatly improved floc formation at approximately the same chemical cost. The plant selected the Hagan Coagulant Aid because operating cost was reduced, since the Hagan Aid could be dry fed. In comparison, the preparation of activated silica sol was a more time consuming task.

COMMITTEE REPORTS TOXICITY FINDINGS

The Technical Advisory Committee on Coagulant Aids for Water Treatment has advised the Chief Engineer of the U. S. Public Health Service that Hagan Coagulant Aids Nos. 7, 11 and 18 are safe and harmless for use in the clarification of drinking water.

Established pursuant to section 301 and 311 of the Public Health Service Act as amended, the Committee examined the toxicological, chemical and physical properties of Hagan Coagulant Aids Nos. 7, 11 and 18.

The Committee judged Hagan Coagulant Aids Nos. 7, 11 and 18 safe and harmless for use in the clarification of drinking water supplies.

WIDE-RANGE APPLICABILITY SAVES TIME, MONEY

Hagan Coagulant Aids are widely used in industry for waste water clarification in the low pH ranges; in hot process lime-soda softeners at high alkalinities and temperatures; in cold, low turbidity water clarification and in waters subject to sudden pH or turbidity fluctuations. They work equally well with all types of coagulants.

Because of their flocculating properties, Hagan Coagulant Aids not only speed up floc formation, but also reduce the amount of coagulant feed required.

WATER PROBLEMS REQUIRE SPECIAL HANDLING

Because no two water supplies are alike and because of seasonal changes in some supplies, there are no stock answers to water problems.

Coagulation studies made on water samples sent to Hagan's Pittsburgh laboratories are, later, confirmed at the plant site on fresh samples. Service available to Industrial and Municipal Plants.

CALGON COMPANY

DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

ALCO steel mains with high-carrying coal-tar-enameled inside surfaces help New York City distribute over a billion gallons of water per day.

Kansas City, Missouri, will be depending on this ALCO electric-welded steel pipe well into the twenty-first century.

STEEL PIPE THAT WILL OUTLIVE A MAN

One hundred years is a long time. Yet that is the estimated minimum life of ALCO electric-welded steel pipe in water-supply installations. Because of the strength of steel and the protection of coal-tar enamel, steel pipe lasts longer and maintains its high carrying capacity.

Municipal engineers know from experience that ALCO electric-welded steel pipe is built to absorb vibration, impact and overloading and provide trouble-free, efficient service for many decades. Its smooth, coal-tar-enameled inside surface assures maximum rate of flow.

Not only is first cost low, but installation of ALCO steel pipe is fast and economical. Sections up to 40 ft in length are light weight and require fewer field joints. Breakage during shipment or installation is virtually impossible.

Sizes of ALCO electric-welded steel pipe range from 20 to 120 inches in diameter and from ¼ inch wall up. For your next piping system, specify *the pipe with the longer life*. For more information, contact your nearest ALCO sales office or write for brochure to: ALCO Products, Inc., Dept. 131, Schenectady 5, N. Y.

ALCO

ALCO PRODUCTS, INC.
NEW YORK
SALES OFFICES IN PRINCIPAL CITIES

LOCOMOTIVES · DIESEL ENGINES · NUCLEAR REACTORS · HEAT EXCHANGERS
SPRINGS · STEEL PIPE · FORGINGS · WELDMENTS · OIL FIELD EQUIPMENT

This open-tank softener has been in continuous service since 1950 using its original AMBERLITE IR-120 resin.

AMBERLITE IR-120 in use over 7 years at oil refinery has treated 3,000,000 gallons of water per cubic foot of resin . . . shows no significant change in softening capacity.

The Gulf Oil Corporation's refinery in Philadelphia, Pa. can produce 3,000,000 pounds of 200 and 680 psi steam every hour for electrical power generation, heat exchange and process use. AMBERLITE IR-120, a strongly acidic cation exchange resin operating in the sodium cycle, is used effectively and economically in the refinery's open bed, gravity-feed softeners to condition 600,000 gallons of water per hour to less than 1 ppm. of hardness.

The AMBERLITE IR-120 at the Gulf Oil Corporation's Philadelphia refinery has been in constant use since 1950 without significant change in capacity or loss of resin—and each cubic foot of resin has treated well in excess of 3,000,000 gallons of water.

While there are many installations which have given such prolonged service, the durability of ion exchange resins is dependent upon the nature of the influent water supply and operating conditions. Engineering companies specializing in water treatment are qualified by experience to give you recommendations on how AMBERLITE ion exchange resins can best serve your specific needs.

If you need softened, deionized, dealkalized or deacidified water, you'll find the answer to your water conditioning problems in our booklet "If You Use Water".

AMBERLITE is a trade-mark, Reg. U.S. Pat. Off. and in principal foreign countries.

Chemicals for Industry

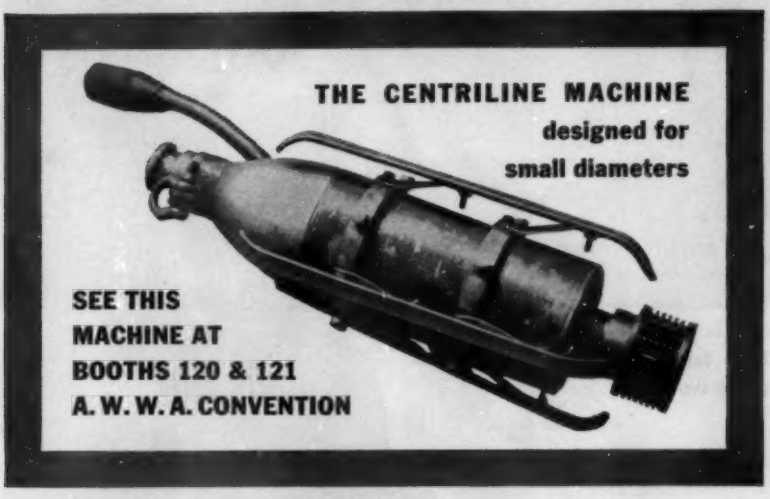
ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

NOW! THE CENTRILINE PROCESS is available for 6" to 14" mains, too!



Yes, your city's small but important transmission and distribution lines can also regain their original flow capacity and pressure through the universally accepted Centriline Process of centrifugally applying a cement-mortar coating to the pipe walls. If some of your lines inadequately serve your customers' requirements, including higher demands for fire protection, investigate the numerous advantages of Centrilining your mains now.

The new, small diameter Centriline Machine eliminates most excavations at valves, laterals and corporation cocks. By eliminating these fixed costs, lengthening the distances between access openings and permitting faster lining speeds, the new Centriline Machine has really reduced the cost of lining small mains. So much so, in fact, that every water works operator should reevaluate the economics of small pipe rehabilitation.

Send today for your copy of our illustrated booklet which fully describes how Centriline can help you salvage worn out pipes from 6" to 144" in diameter permanently and for much less than you would imagine.

CENTRILINE CORPORATION

A Subsidiary of Raymond Concrete Pile Company

140 Cedar Street
New York 6, N. Y.
WOrth 2-1429

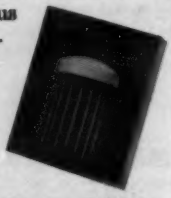
Branch Offices in Principal Cities of the United States, Canada and Latin America.

MODERN WATER STORAGE at Pueblo, Colorado

750,000 gallon tank on 120 ft tower.
Diameter 62 ft. Head range 35 ft.

by
Pittsburgh-Des Moines

These fine-appearing PDM Radial Cone Elevated Steel Tanks serving the city of Pueblo typify the value, craftsmanship and dependability inherent in Pittsburgh-Des Moines water storage units of every type. Full information on the various designs, with tables of capacities and numerous photographs, are presented in our 20-page Elevated Tank Brochure. Write for your copy.



1,500,000 gallon capacity tank on 70 ft tower. Diameter 88 ft. Head range 35 ft.

PDM
ELEVATED STEEL TANKS

Pittsburgh-Des Moines Steel Company

Plants at PITTSBURGH, DES MOINES, SANTA CLARA, FRESNO, and CADIZ, SPAIN

Sales Offices:

PITTSBURGH (25) . . . . 3424 Neville Island
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CHICAGO (3) 628 First National Bank Bldg.
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DES MOINES (8) . . . . . 925 Tuttle Street
DALLAS (1) . . . . . 1229 Praetorian Bldg.
SEATTLE (1) . . . . . Suite 332, 500 Wall St.
SANTA CLARA, CAL. . . . 631 Alviso Road
DENVER (2) . . 323 Railway Exchange Bldg.

It takes just two steps to assemble the FLUID-TITE Coupling. Lubricate the tapered edge of the gasket. Then slide in the pipe.

Major Advance in Waterworks Industry. K&M's exclusive FLUID-TITE Coupling provides permanent, water-tight, root-tight connections.

SLIDE IT IN QUICK... IN 2 EASY STEPS

IT'S "K&M" ASBESTOS-CEMENT PRESSURE PIPE WITH EASY-TO-INSTALL FLUID-TITE COUPLING

Installation is fast and economical! It doesn't require skilled labor, heavy machinery, or heavyweight coupling pullers. Install it in any weather.

The seal grows tighter as the pressure climbs! Coupling rings expand as water mains fill. Rings have holes on one side for self-energizing action.

It's practically indestructible! "K&M" Asbestos-Cement Pressure Pipe is non-tuberculating, non-electrolytic, and corrosion-resistant. Its first cost is often the last cost. Pressure remains normal—pumping costs stay low.

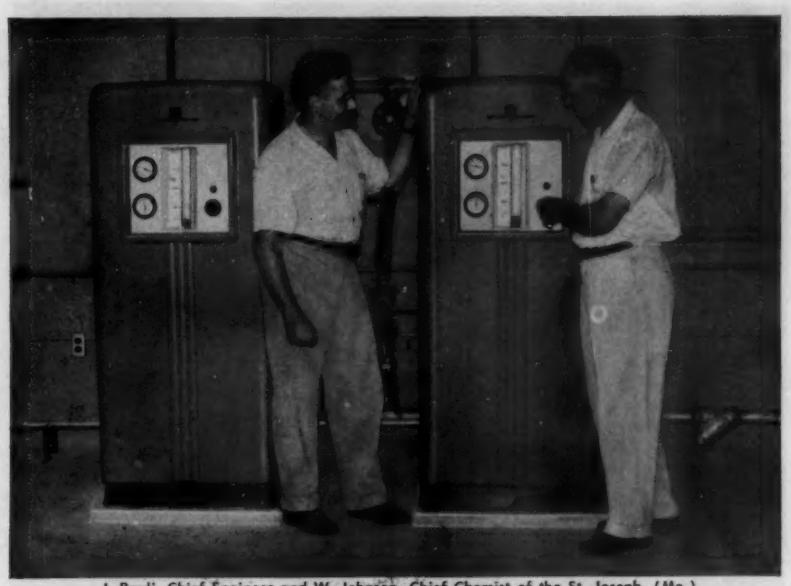
Visit our booth Nos. 52, 53—AWWA Convention, Dallas Memorial Auditorium, April 20-25.

K·M

BEST IN ASBESTOS

KEASBEY & MATTISON

COMPANY • AMBLER • PENNSYLVANIA



J. Pauli, Chief Engineer and W. Johnson, Chief Chemist of the St. Joseph, (Mo.) Water Company, discuss operation of their W&T V-notch chlorinators. The St. Joseph Water Co. is part of the American Water Works Service Co., Inc. system.

W & T V-notch Chlorinators — doubly accepted

The St. Joseph Water Co. found breakpoint chlorination the best way to treat Missouri River water. But this increased the range of chlorine requirements in the water treatment. W&T V-notch chlorinators were the answer.

W&T V-notch chlorinators have a chlorine feed range of 20 to 1 with an accuracy of 4%. Based on this acceptance at its St. Joseph plant, the American Water Works Service Co., Inc. has purchased V-notch equipment for use in other plants.

V-notch chlorinators are available to feed from 2½ to 8000 pounds of chlorine per 24 hrs. V-notch equipment also provides permanence and attractiveness through modern reinforced plastics. For comprehensive information about W&T V-notch chlorinators, write for Bulletin S-122.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 50 • APRIL 1958 • NO. 4

AWWA Public Information Program

Ad Hoc Committee Report

A report of the activities of the Ad Hoc Committee on Public Information for the year ending Dec. 31, 1957, submitted to the AWWA Board of Directors on Jan. 27, 1958, by John H. Murdoch Jr., Consultant. A summary of this report was published in the Secretary's Letter in Willing Water *No. 50, February 1958.*

THE AWWA Ad Hoc Committee on Public Information was created to consider areas in which better public information concerning water service is needed and to suggest means by which the needed information could be brought to public attention.

The committee believes that an informed public is a priceless asset of a community water works.

The conclusion has been reached that the public and water works management need greater appreciation of the contributions which water supply agencies have made to community well-being. The committee has also concluded that water service must be improved, and that the public and management need to realize that fact and be led to anticipate with pleasure the benefits to result from such improvement. Of at least equal importance is a realization that good and improved water service depends on adequate revenues.

The committee believes that its thinking represents the consensus of the membership of AWWA and also of those engaged in the fields of public health, public works, water conservation, and community betterment. Briefly stated, the committee believes that there is an imperative present need for improved water service, and that the public and water utility personnel must now and in the immediate future be informed of this need and of all that must be done to meet it—for the sake of the communities served.

Present Shortcomings

Water service is so intimately related to public health, public safety, the comforts, conveniences, and essentials of domestic life in urban centers, and

to the growth and prosperity of those centers that any failures or shortcomings in water service are too many.

Although confident that water supply agencies have done and are now doing valuable and essential public work, the committee believes there are are too many failures. As to water quality and safety, there are relatively very few failures, but those few are too many. As to personnel, water service is too important, too involved, and has too many opportunities for costly mistakes to be entrusted to or to be placed in the control of any but professionals. There are relatively few, but too many, untrained amateurs in responsible positions in water works. There are many —hundreds or even thousands—of water systems which are not able to fulfill the utility's function of supplying water, where and when needed. Far too many water systems are inadequate to meet the growing needs of growing communities.

Neither the public nor some of the water utility personnel are informed of these things nor realize all that is involved in bringing about the improvements needed. The committee suggests that AWWA undertake an operation looking toward the immediate improvement of water service through a public information program.

In the outline which follows, the committee does not attempt to develop fully all the various lines of work or thought which are mentioned. The lines of thought are given merely as illustrations, not as exclusive approaches. The committee hopes to have prepared short—three- or four-page—developments of various important lines of thought for suggestions for water utility speakers or for advertisers. As illustrations, such short developments should be prepared on "Water Works and Public Health" and on "What Is an Adequate Water Supply?" The booklet "Good Water and Plenty of It" * contains much valuable material and should be widely used in public relations work.

With this introduction, the committee now presents an outline and some explanation of a typical operation. This will include recommendations for action.

Operation Water Works Advancement

SLOGAN: Good Water, the Lifeblood of Your Community.

OBJECTIVE: Improved water service, through water works systems self sustained and adequate to meet the growing needs of each community.

I. Roadblocks

A. Lack of Public Appreciation of:

1. Part played by water works systems in public health improvement by making safe water available to all takers and by providing means for community sanitation and pleasant living

2. Part played by water works systems in reducing fire hazards and insurance rates

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3. Part played by water works systems in making industrial growth and community expansion possible.

B. Lack of Realization on Part of:

1. Water works managers of the fact that:

a. Relatively minor acts of discourtesy toward customers or the public, or failure to be thoughtful and considerate, create bad impressions and lead to dislike and active opposition to needed action.

b. Since water works systems are expected to supply the community with pure water, the community will be unfavorably impressed by sloppy appearances in personnel, properties, equipment, or on construction projects.

c. Close cooperation with the newspaper leg men, as well as with the editors, managers, and owners, is essential if the true story of a developing water system is to be fairly presented.

d. The public wants water system results rather than excuses for failures in service, and limitations on service as to quantities, times, and places, or even occasional poor quality are considered by the public to be failures in service.

2. Customers and the public of the fact that:

a. Individual customers are constantly increasing their water uses and demands.

b. A growing community must have a growing water system to supply more customers, as well as more use by individual customers.

c. Supply systems must be adequate to meet service needs in periods of drought.

d. The continued prosperity and the future growth of the community, as well as the comforts of living, depend on having the community water system kept constantly ahead of demands, with reasonable provision for the unexpected and for adverse conditions.

e. Such water systems under present market conditions covering labor and materials are much more expensive than in the past, and financing their construction costs and the operation and maintenance of the entire system must be supported by realistic rates.

f. Managing and operating a water system are fields for qualified personnel and should never be put into the hands of amateurs.

C. Lack of Anticipation on Part of:

1. Water works managers of:

a. Growth and change in quantity and quality demands

b. Geographical expansion of service demand areas

c. Safe yields of existing and possible future and ultimate sources of supply

d. Impact of competitive uses for available water resources

e. Reservoir silting, resulting from land use and its effect on safe yields

f. Time lags involved in developing plans for and completion of facilities or programs required to be ready for growing demands ("In the business of water supply, 10 years from today is now.")

g. Advancing costs of construction and of operation.

2. Customers and public of:

a. The sense of well-being of a community with a water works system designed, constructed, and in operation, adequate in quantity not only for present needs but for anticipated needs, and adequate for possible adverse con-

ditions, and also safe, palatable, and fully satisfactory in quality

b. Comfort of having water when, where, and as needed.

II. Plan of Campaign

A. Forces to Be Enlisted:

1. Local water works managers and personnel
2. Engineers and others with specialized training
3. American Water Works Association
4. Manufacturers of water works equipment and supplies.

B. General Comment on Plan:

Each of these forces must be asked to carry part of the burden, and each must support the work being done by the others. This is a forward movement by the industry for the benefit of all urban communities and its success depends on energetic, imaginative cooperation by all segments of the industry. Operation "Water Works Advancement" must keep attention focused on the ultimate objective—improved water service through water works systems, self-sustained, and adequate to meet the growing needs of each community and the slogan "Good Water the Lifeblood of Your Community." The roadblocks must be kept in mind, however, and plans for reaching the ultimate objective must involve the overcoming of these obstacles.

C. Group Assignments:

1. Water works managers and personnel:

The first duty of this group is to eliminate local friction. This might seem a small matter, but it is one of the most important parts of the entire operation. Where there is antagonism to the local utility because of discourtesy, thoughtlessness, poor organization, inefficiency, lack of attention to appearances, and lack of close contact with newspaper men, officials, and service clubs, there will be great difficulty in bringing public appreciation of the importance of water works. There will certainly be skepticism rather than anticipation of future benefits. Local water works personnel must earn, and deserve to hold, local respect and confidence.

First of all, and always, management must get the best possible service for the customers and the public out of the system as it exists. The people will fight proposals to spend money on improvements recommended by officials who are wasteful of available resources. The improved and strengthened systems needed will be provided if the public has confidence in management.

Use can be made of the various aids on improving public relations prepared by AWWA. These should be studied and their lessons learned and applied.

Local management can do much to remove the roadblocks of lack of appreciation, realization, and anticipation, by arranging to have AWWA advertising materials carried in local papers at the expense of the local system or of local groups interested in community progress. Lack of public appreciation could, in part, be overcome at little cost by encouraging school projects on water and water works, making use, perhaps, of the excellent visual education materials developed in cooperation with the staff of AWWA. Finally, it is suggested that local management should seek out opportunities to have AWWA speakers address local governmental bodies, PTA groups, service clubs, and any other groups that are interested in community problems.

The local manager must make himself a respected and recognized part of his community, whose word and whose professional integrity can be counted upon. He must show himself able to plan for the future with intelligence and courage; he must anticipate needs and prepare to meet them. He must be a salesman who can build up community anticipation of the joys of an adequate water system, so that its cost will seem small compared with its advantages.

The costs are great in mental wear and in energy, but in dollars, practically nothing.

2. Engineers and others with specialized training:

The principal function of this group should be in developing and guiding the thinking of water works men and the AWWA in the meaning of "adequate in quantity and satisfactory in quality" when applied to community water systems, and in developing economically sound reasoning on the financial problems involved. These persons should be asked to prepare, present, or publish papers on such matters and to give general advice and guidance to AWWA speakers on lines of thought and on underlying principles. They should not be expected to give detailed advice on specific local situations unless retained and paid for services by the local interests. Their help would be invaluable in helping to staff management seminars or training courses for water works managers.

3. American Water Works Association:

Article II of the Constitution of AWWA sets out the objects of the Association. The planned "Operation Water Works Advancement" is designed to carry forward these objects and in no particular to go outside of them. This may be important to the Association legally. The Association in all of its work in the operation must be careful to keep always in mind the ultimate objective. The ideal is adequate and satisfactory service. The realistic rates essential to such service are means to that ideal.

The AWWA should remember Subparagraph b of Article II of its Constitution which reads: "to consider and deal with the problems involved in the production and distribution of safe and adequate water supplies"; the operation is designed to acquaint the water works officials and the public with the meaning of adequate water supplies and with how to deal with the problems involved. Further, the Association is authorized by the quoted paragraph to deal with the problems, not merely to consider them. It is proposed in the operation to have AWWA deal with the problems involved by helping to create a favorable climate of opinion.

How can AWWA be useful in the operation without exceeding a reasonable budget appropriation? It is understood that the 1957 budget contains $20,000 which could have been used in advancing the suggested operation. The assignments of duty stated below are recommended for immediate approval and execution. A higher appropriation would be needed to cover the cost.

a. Restudy of AWWA pamphlets and bill stuffers is required to be certain the emphasis is properly placed on good, improved and adequate service rather than increases in rates; on the importance of adequate and satisfactory service, rather than cheap water; and on the good work that has been done and the present critical need for more work requiring more money for local water works.

b. Revision of existing material where required and the preparation of new material for distribution should support the operation and point toward the objective.

c. One or more series of advertisements in support of the operation should be prepared, to be made available to the members of the Association for their use in local advertising. It is suggested the series be prepared by professional talent under AWWA supervision and be made available to the membership at the approximate cost. Something of a similar nature might be done for use in local editorials, if editors' sensibilities would not be hurt.

d. Preparation of a water works movie featuring the operation and designed to acquaint the public and water works personnel with the importance of water service, the need for improved service, and the financial problems involved in such improvement. The movie should be professionally prepared, limited to 15 min, be of 16-mm size, and be available for water works speakers to use in presenting the operation to any interested group. The California Section could be helpful in planning and arranging for such a movie under the supervision of the AWWA headquarters staff. If it were found that the cost of such a movie would be more than the budget would justify, its place could be partly filled by the movies named below.

Good use could be made of presently available movies prepared by manufacturers and state agencies and dealing with water service subjects. AWWA staff personnel might prepare a list of such movies, including in the list only those viewed and found to be worthy of AWWA endorsement.

e. Organization and training of groups of speakers in each section should be emphasized, to enable members of the various groups to be prepared and ready to accept invitations to speak—on the operation and in support of the objective—before any and all groups which should be interested from a professional or community improvement standpoint. These speakers might well be thought of as having the duty to call water works personnel and the public to action. The groups need not be limited to water works personnel, but might include any public spirited persons. The AWWA should suggest ideas for development by the speakers and might even prepare outlines and some vital paragraphs where requested, but the members of the groups should be forceful speakers in their own right, and their own personalities, ideas, and enthusiasm must shine through. Ghost-written or canned speeches should be avoided. Local management, the AWWA, and manufacturers can help in this work by securing invitations for speakers. The movies mentioned above could be used by the speakers. The use of animated charts should be developed. Many valuable ideas can be found in the booklet, "Good Water and Plenty of It."

There should be enough speakers in each section, and they should be so located that the time and expense of reaching speaking points would not be burdensome. A booking committee in each section should assign speakers and should establish contacts with program chairmen of various organizations to secure invitations for appearances.

f. The operation should be placed on the programs of the various sections of AWWA for section meetings and, of equal importance, carried forward as a continuing yearly operation within the sections. Presentations in all cases

should be made by trained speakers fully dedicated to the operation and its objectives. The operation and its objective come within the field of interest of each of the divisions of the AWWA, and division officers should be asked to give it prominence in their work.

g. Manager's seminars or short training courses should be organized to help water works men learn how to manage their systems, how to improve those systems, and how to improve their employee and public relations. Such seminars or courses should be held free of convention distractions, but in cooperation with the Association sections. Additional staff personnel should be charged with pushing this phase of the work and with advancing the Operation.

h. Articles should be written of a type and in a style which would make them salable to the national magazines of general circulation; articles should also be written articles designed for business, professional, or trade publications. AWWA could undertake to interest members with writing ability and with standing outside of water works, as well as within the field, whose written ideas carry weight.

Items *a–c* would not involve expenditures requiring an increase in budget items. Item *d*—a professionally prepared movie—if done along the lines of "Pipeline to the Clouds"* might cost as much as $50,000 or as little as $25,000. The committee has been told that there are at least two movie companies in the East that could do a good job for about $10,000. The committee hesitates to recommend either the $50,000 or the $10,000 film. In view of the fact that there are many good movies already available at practically no cost to AWWA, it recommends that the matter of a special AWWA operation movie be given further study and be considered at the meeting of the Board during the 1958 Conference.

Items *e–h*, if carried forward, would involve expenditures for travel, and if additional staff were employed, there would be salary and clerical help to consider. The management seminars or short courses could be made partially self-sustaining. The committee feels that additional staff with responsibility for advancing the movement and getting the management training plans in operation could do the work.

The committee estimates that a budget appropriation for all items above except the professional movie of $20,000 should be ample for the year 1958. It is estimated that this work would probably require an appropriation for 1959 of approximately $30,000. The committee believes that *Willing Water* could be useful to the program and may require additional budget appropriation.

If, in the future, AWWA directors saw fit to increase the budget appropriation, more work could be done. More use could be made, advantageously, of the services of trained general writers, advertising copy men, public relations men, and of speakers requiring fees and expenses. The expense involved would be about an additional $30,000. It is suggested that the directors should give careful thought to appearances. An obviously high-cost program might result in a public questioning of the good faith of the Association. Perhaps the operation and the objective have such public value that anything which looks like costly overselling would be harmful.

* Produced by General Electric Co., Schenectady, N.Y.

4. Manufacturers of water works equipment and supplies:

The group designation used was chosen rather than the WSWMA because some of the suggested assignments would be for individual members of that association while others would be strictly association business. The WSWMA has engaged a public relations expert who is carrying forward a program designed to focus the attention of the public on the importance of water. The work is well begun and should not be given up. In the long run it will have beneficial results for water utilities, but it will have no immediate effect in advancing improvements in water works systems. Immediate means within the next 5 years, when improvements in service must be provided. The AWWA operation and the WSWMA program can be mutually helpful. Certainly the two associations are working along generally parallel lines. The first suggested group assignments are for WSWMA to work through its public relations expert. Other suggestions will be for association action outside of that employment and for action by members of the AWWA.

a. The WSWMA expert can be helpful to AWWA in its operation without going beyond the scope of his employment contract with that association, and, indeed, in direct furtherance of that contract as the committee understands it. The following are suggestions:

(1) Consultations can be held with officers and committee members on lines of approach to groups to be interested in the AWWA operation.

(2) Through the expert's connections with other groups and his contacts, he can cause invitations to be extended to AWWA speakers on the operation for various programs.

(3) The expert's connections and influence can get national periodicals, trade, professional, and technical publications to publish articles in support of the AWWA operation.

(4) The expert's best efforts can cause other organizations with which he has established relations to recognize the AWWA objective as a worthwhile project.

b. WSWMA could be helpful with relation to its public relations expert and in persuading its members to support—as individual companies—the AWWA operation and to recognize and approve its objective by a formal endorsement. It would be helpful if the endorsement carried with it an instruction to its expert to cooperate as suggested above.

c. Individual members of WSWMA can do a tremendous job for AWWA and its operation:

(1) Within their regular advertising budgets, they can feature the AWWA operation and objective in such ways as may seem best to each. Where the member usually carries on national advertising outside of trade journals, the material could be directed to the general public. If the advertising is limited to trade journals, it could be directed to arouse the interest of water works people or governmental officials.

(2) The AWWA operation could be featured in company exhibits, so that those who attend meetings would have constant reminders.

(3) Sales representatives have great personal influence with water works personnel, and those sales representatives should be trained and instructed to preach the importance of

the operation on all appropriate occasions.

All of the suggested lines of effort to be assigned to the WSWMA, its expert, and its members can be adopted and followed at no expense outside of their normal budgets.

National Advertising

The committee has been giving consideration to a national media advertising campaign to be carried on in the name of AWWA. The cost of such an undertaking would be between $300,000 and $500,000 a year and, if undertaken, should be continued for at least 3 years. The matter is still under study by the committee, and it does not at this time make any recommendation on it.

Recommendations

The committee believes: [1] that a public information operation should be instituted at once and carried forward with vigor; [2] that the public, community officials, and water works personnel must be better informed on the importance of water works in community life, of the need for improvements in water service, and that good service and improvements depend on adequate revenues; [3] that AWWA owes a duty to the public and to its members to lead toward improved water service and toward improved training for water works managers.

The committee further believes that an informed public is a priceless asset of a community water works and that such an informed public will want improved water service, through water works systems self sustained and adequate to meet the growing needs of each community.

The committee recommends that:

1. "Operation Water Works Advancement" be authorized with directions that it be actively promoted beginning at once

2. Close liaison be maintained by the committee with the WSWMA, particularly concerning national advertising by its members; that the WSWMA president and its public relations committee chairman be added to the AWWA Ad Hoc Committee on Public Information; and that the WSWMA and its members be invited to support the committee's work along the lines outlined in the committee report

3. A member of this committee be made chairman of a subcommittee composed of himself, the chairman of WSWMA, and the public relations committee chairman, to maintain liaison with the WSWMA

4. In order to develop the AWWA public information operation, a qualified man be appointed as field representative

a. This man should be capable of developing and should develop management seminars in various sections and regions through the national office and section officers, possibly with different approaches in different areas, and the seminars should not be considered a part of section meetings.

b. The field representative should meet with members or groups of members in various areas to thrash out specific management problems. In these idea exchange sessions, the field representative can bring to the voluntary groups, without side distractions, ideas of value from other areas and add to his own basic knowledge for further distribution.

c. The representative should carry the message of good management to small, but interested, groups.

d. He should aid in developing speakers' bureaus.

e. He should aid in publicity development.

f. He should speak at and aid in developing programs for section meetings on management.

g. He should aid in developing seminars for the smaller cities through nuclei of good managers.

h. He should aid in developing new material for public information.

5. That this committee be continued until such time as the public information program is considered implemented, its results weighed, and its future success assured

6. That the Directors of AWWA make a budget appropriation for the approved work of the Ad Hoc Committee on Public Information for the year 1958.

[The committee report and its recommendations were approved by the Board of Directors on Jan. 27, 1958.]

Safety of Certain Coagulant Aids for Potable-Water Treatment

In 1957 the US Public Health Service, in response to requests from health and water works officials and others having responsibility in the field of water supply, established the Technical Advisory Committee on Coagulant Aids for Water. The group's function is to receive information from producers and purveyors about the composition and toxicity of coagulant aids, to review it, and to advise on the safety of such materials for use in treating drinking water. Major manufacturers of coagulant aids were notified of the committee's formation and were invited to submit information on their products.

The committee, through the assistant surgeon general, has now advised that, on the basis of information submitted on certain coagulant aids, the specific materials examined may be used in treatment—in the concentration recommended by the manufacturer—without adverse physiological effect on those consuming the water. The committee has not inquired into the effectiveness of these materials for the proposed use and does not imply that the products are necessarily superior, equivalent, or inferior in performance to other products intended for similar use.

The manufacturers and products referred to above are:

Hagan Chemicals & Controls, Inc., Pittsburgh, Pa. (Hagan Coagulant Aids No. 7, 11, 18)

Stein, Hall & Co., Inc., New York, N.Y. (Jaguar)

The Permutit Co., New York, N.Y. (Permutit No. 65, 66, 67)

E. F. Drew & Co., Inc., New York, N.Y. (Drewfloc)

Hercules Powder Co., Wilmington, Del. (Carboxymethylcellulose)

Natural and Synthetic Polyelectrolytes as Coagulant Aids

Jesse M. Cohen, George A. Rourke, and Richard L. Woodward

A paper presented on May 14, 1957, at the Annual Conference, Atlantic City, N.J., by Jesse M. Cohen, Chemist, George A. Rourke, Chemist, and Richard L. Woodward, Chief, Water Supply Unit, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

ONE of the essential processes of the majority of water treatment plants involves the addition of a chemical coagulant which causes aggregation of some fine particles and adsorption of others to produce a larger particle called a floc. The settling rate of this floc is dependent on many factors, but principally on its size and density. Considerable research over the past years has been directed toward achieving a fast-settling floc. A major contribution to this effort was the discovery that activated silica induces the formation of large, dense, and tough floc. There has been no serious competitor to activated silica for water clarification until the recent introduction of natural and synthetic materials called polyelectrolytes. It was soon apparent that these materials are effective coagulant aids, which produce a large and rapidly settling floc when used with standard chemical coagulants.

In spite of the fact that production of polyelectrolytes for use in water treatment has been developed by several large chemical companies in the past 3–4 years, very little has been reported in the literature on the use of these new compounds. A notable exception is a paper by Johnson (*1*), who reported on the effect of polyelectrolytes, alone and in conjunction with metal coagulants, on chemical coagulation of some synthetically modified surface waters, and on process waste waters. Both natural (starch) and synthetic (polycationic and polyanionic) polyelectrolytes were investigated. Johnson concluded that "polyelectrolyte coagulants showed such promising results in the systems studied that they could become an important supplement to coagulants now used for clarifying waters."

Reports on the use of polyelectrolytes in treatment of industrial waste waters have been fairly numerous, especially in ore-dressing and coal-washing operations (*2–6*). A recent intensive investigation on the use of these materials was made by LaMer and Smellie (*7*), who reported on the flocculation, subsidence, and filtration of polyelectrolyte-treated phosphate slimes. Modified starch was found to be an effective low-cost flocculant.

Chemistry

The generic term polyelectrolyte describes a variety of compounds, some of which have been found to be effec-

tive coagulants and coagulant aids. Their use may seem to be a new development in the field of coagulation; the process is, in fact, at least 4,000 years old. Sanskrit literature, about 2000 B.C., suggested a number of vegetable substances, notably the seed of *Strychnos potatorum*, as a means of clarifying water. It now seems fairly clear that such organic compounds as starch and starch derivatives, cellulose compounds, polysaccharide gums, and proteinaceous materials may be used as coagulant adjuncts. In spite of their varied sources, these compounds may be collectively described as biocolloids, which are naturally occurring polymers carrying electric charges or ionizable sites.

An important development in colloid chemistry has been the production of synthetic polymers with high molecular weight, analogous in general properties to the biocolloids. All of these compounds contain recurring units of small molecular weight, chemically combined to form a molecule of colloid size, and each of the recurring units carries one or more electrical charges or ionizable groups. Because these compounds have the characteristics of both polymers and electrolytes, they have been called polymeric electrolytes, or, more frequently, polyelectrolytes.

One of the first synthetic polyelectrolytes studied was polyacrylic acid, a polymer of repeating units of acrylic acid. The similarity between this purely synthetic compound and a naturally derived polyelectrolyte such as starch exists in the fact that both compounds are polymers of repeating units, acrylic acid and glucose, and that each of the recurring units contains ionizable groups, carboxyl in one and hydroxyl in the other. These ionizable groups are readily converted to strongly ionized sites by reaction with alkali.

Three general classes of polyelectrolytes may be obtained, depending on the sign of the electrical charges. Negatively charged compounds, such as caustic hydrolyzed polyacrylamide, are called anionic polyelectrolytes, while polymers carrying a positive charge, such as polyvinylpyridinium butyl bromide, are termed cationic. In addition to these polyelectrolytes with charges of one sign, compounds can be prepared, called polyampholytes, that have both positive and negative charges. Proteins and some polypeptides provide a wide range of natural polyampholytes.

Methods of Study

Work at the Robert A. Taft Sanitary Engineering Center was undertaken to investigate the utility of some commercial polyelectrolytes in coagulation of surface waters and of laboratory-prepared turbid water. Since polyelectrolytes are an extremely diverse group of chemicals, it is patently wrong to generalize on their behavior. For this reason, the laboratory work was divided into three phases:

1. Work done with a synthetic anionic polyelectrolyte
2. Work done with a synthetic cationic polyelectrolyte
3. Data obtained with a natural polyelectrolyte.

In all of the coagulation work, a stirring apparatus was used which allowed the simultaneous testing of six 2-liter aliquots of sample. Procedure of testing was standardized to permit comparisons between individual coagulation runs. A typical test was performed in the following way: 2-liter portions of well mixed test water were put into each of six square-sided gallon

jars in place under the machine. Measured amounts of both the metal coagulant, generally alum, and the polyelectrolyte under study were put in small individual beakers resting in front of each sample of test water. This procedure provided the means for adding the dosing chemicals quickly and accurately while the stirrer was operating. Flocculation was allowed to proceed for 30 min at 42 rpm, which provided a paddle tip velocity of 43 fpm. After coagulation, the contents were allowed to settle for 30 min, during which time settling quality of the floc and degree of clarification were determined according to a procedure developed in this laboratory (*8*). In this procedure, the rate of settling of a floc is determined by withdrawing samples simultaneously from each of the six jars and measuring the amount of turbidity in each sample. From these data a curve is obtained which provides an accurate description of the settling characteristics of the floc. Turbidity measurements were made with a spectrophotometer at a wave length of 470 mμ, using a 5-cm cell. A reference turbidity was prepared by suspending finely ground clay in distilled water and calibrating with a Jackson candle turbidimeter.

To eliminate the variables occurring in natural waters, a soft turbid water described by Smith and others (*9*) was prepared in the laboratory. Since this water is easily reproducible, any changes obtained in the quality of a coagulation could be justifiably ascribed solely to any added variable. Thus, improved coagulation resulting from addition of polyelectrolyte, for example, could be due only to this compound and not to a change in test water quality. A local clay was suspended in distilled water, allowed to stand, and the supernatant was then siphoned off for a stock turbidity. Microscopic determination of particle size distribution showed that 85 per cent of the particles were 1–3 μ, 11 per cent were 3–5 μ, and 4 per cent were over 5 μ in size. Particles of less than 1 μ were not measured. Alkalinity was provided by adding sodium bicarbonate.

In addition to the laboratory-prepared turbid water, other natural waters, varying widely in degrees of turbidity, hardness, and alkalinity, were used. To insure that water of unvarying quality was being tested in any one series of experiments, 25–30 gal were collected and combined in a single tank equipped with a mechanical stirrer. Chemical and physical tests showed that the water characteristics did not change during the testing period, which generally lasted about 1 week.

Reagent grade aluminum sulfate corresponding to the chemical formula, $Al_2(SO_4)_3 \cdot 18H_2O$, was used in all coagulations. Three commercial compounds representing three classes of polyelectrolytes were studied in detail:

1. *Anionic A:* a synthetic, high-molecular weight, acrylamide polymer hydrolyte. Partial hydrolysis of polyacrylamide results in the replacement of some of the amide with carboxylate groups, thus converting an uncharged polymer to an anionic polyelectrolyte. The compound is supplied as a white amorphous solid in the form of small flakes, from which solutions may be prepared.

2. *Cationic B:* an amber-colored, slightly viscous, caustic liquid. This solution contains an organic cationic polymer in an approximately 1*N* caustic solution. Since it is miscible in all proportions with water, dilute solutions

for feeding in water treatment are readily made.

3. *Nonionic C:* a representative of the naturally derived polyelectrolytes. It is supplied by the manufacturer as a physical mixture of polyelectrolyte and clay. Qualitative tests in this laboratory have shown that the active ingredient is a cellulose derivative, probably similar to carboxymethylcellulose.

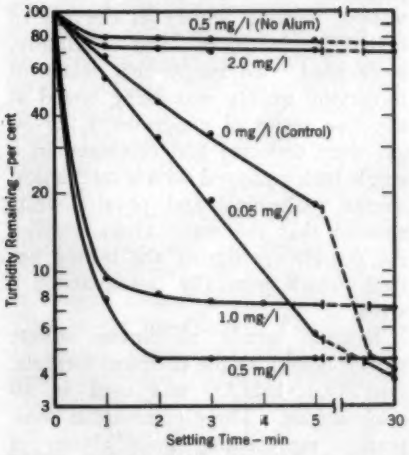

Fig. 1. Effect of Anionic *A* on Synthetic Turbid Water

Anionic A *was added to jars of laboratory-prepared turbid water in amounts shown. All solutions contained 10 mg/l alum, except the one designated as containing none.*

Anionic *A*

In preliminary work with Anionic *A*, laboratory-prepared turbid water was used as the test water. Turbidity of this water ranged from 90 to 110 units and alkalinity varied from 50 to 54 mg/l as calcium carbonate.

Since Anionic *A* would represent one of several chemical compounds added to a coagulation, it was necessary to determine whether it should be added before or after metal coagulants, such as alum. Results showed that Anionic *A* could be added to this test water at any time before or after the addition of coagulant. It was also effective, although to a much lesser extent, when added after alum floc had been fully formed. Since slightly superior results were obtained when Anionic *A* was added simultaneously with or any time before the addition of alum, the latter procedure was followed in all additional work with this compound. Subsequent work has shown, however, that optimum time for addition of Anionic *A* varies with the individual water being examined.

Optimum Concentration

The optimum concentration of Anionic *A* to use with the laboratory-prepared turbid water was determined by adding increasing amounts of polyelectrolyte to a coagulation obtained with 10 mg/l alum. Criteria for judging coagulation quality were the settling rate and the residual turbidity after 30 min settling.

The principal effect of polyelectrolytes on a coagulation is a large increase in floc size, which can be demonstrated analytically by the greatly accelerated settling rate of the floc. This effect is amply shown in Fig. 1. The lowest dose tested, 0.05 mg/l of Anionic *A*, produced a faster settling floc than that obtained in the control jar, where 10 mg/l of alum alone was used. Maximum benefits—a high settling rate and a low residual turbidity—were obtained with 0.5 mg/l. When the concentration of Anionic *A* was increased to 1 mg/l, some decrease in benefits was observed in the form of higher residual turbidity, while 2 mg/l interfered to the point of complete inhibition of coagulation. Results obtained

by adding 0.5 mg/l of Anionic *A* without addition of alum demonstrates that this polyelectrolyte is not a coagulant but rather a coagulant aid, dependent on the prior formation of a floc by some metal coagulant.

The required amount of Anionic *A* for a satisfactory alum coagulation of any particular water would, of course, have to be determined empirically, much like the determination for the necessary amount of coagulant. To obtain maximum benefits with laboratory-prepared water, it was found that the concentration of Anionic *A* must be increased linearly with increase in alum dose. It should be emphasized that increased settling rates may also be obtained with lesser amounts of Anionic *A* and that the above relationship represents the maximum benefits obtainable.

Miscellaneous Observations

Several experiments were made to determine the effects of such factors as pH, alkalinity, hardness, and turbidity on the use of Anionic *A*. It was shown that Anionic *A* does not extend the range of pH at which alum coagulation could be accomplished. Where a good coagulation was obtained with alum, the addition of Anionic *A* did a better job. With pH values that gave unsatisfactory alum coagulation, the addition of Anionic *A* had only a slightly beneficial effect. These experiments further emphasize the point that prior production of a floc with alum is a requisite for the benefits obtainable from Anionic *A* treatment.

Increased settling rate was obtained with Anionic *A* in a wide range of alkalinity, 5–300 mg/l, in the presence of varying degrees of hardness, 0–1600 mg/l, and with turbidities from 50–540 units. With synthetic turbid water, Anionic *A* was shown to be remarkably unaffected by chemical and physical changes of the test water.

TABLE 1

Effects of Anionic A Additions to Alum Coagulation of Natural Waters

Test Waters	Ohio River	Miami River	Pond *D*	Pond *P*	Pond *B*
Turbidity—*units*	54	35	380	89	464
Hardness (as $CaCO_3$)—*mg/l*	106	280	48	70	49
Alkalinity (as $CaCO_3$)—*mg/l*	42	204	43	51	36
pH	7.6	8.1	7.6	7.8	7.5
Color—*units*	Low	20	47†	58†	50
Alum*—*mg/l*	15	15	55	50	70
Anionic *A*—*mg/l*					
Optimum	1.0	0.5	3.5	4.0	8.0
Effective range	0.25–1	0.25–1	2–6	2–4	4–8
Interference	2.0	2.0	>6.0	6.0	>12.0

* Minimum amount of alum for satisfactory coagulation.
† Slight improvement in color removal with Anionic *A*–treated samples.

Natural Waters

It was clear from the work on synthetic turbid water that Anionic *A* dramatically increased the settling rate of alum floc. The effects of small additions of Anionic *A* were then checked on five natural waters, obtained locally and varying greatly in chemical and physical characteristics. In these stud-

ies, each water was tested to determine the minimum amount of alum needed to yield a good coagulation. Using this established amount, a series was then set up by adding increasing amounts of Anionic *A* to determine the combination of alum and Anionic *A* which would yield the highest settling rate plus low residual turbidity. These data are summarized in Table 1.

With all of the five waters tested, Anionic *A* treatment greatly increased the settling rate of the alum floc. As previously pointed out, increased amounts of Anionic *A* were necessary as the alum dose was increased. Slight improvement in color removal with Anionic *A*–treated samples was obtained in Ponds *D* and *P*. Attempts to coagulate Pond *D* water by adding as much as 5 mg/l of Anionic *A* without additional metal coagulant were not successful. These tests further show that Anionic *A* is a true coagulant aid requiring the presence of a metallic-coagulant floc to clarify turbid water.

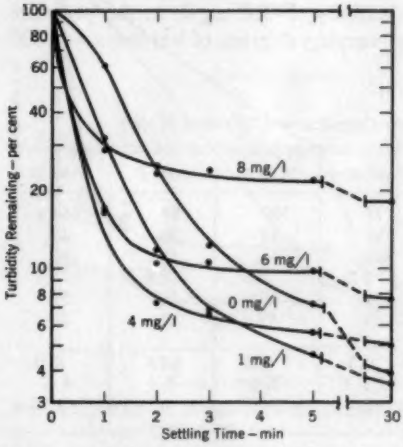

Fig. 2. Effect of Cationic *B* on Cincinnati Tap Water

Cationic B *was added to turbid Cincinnati tap water in amounts shown. All solutions contained 10 mg/l alum.*

Summary

The salient facts which emerge from the laboratory testing of Anionic *A* may be listed as follows:

1. Anionic *A* is not a coagulant, but a true coagulant aid, which requires the concomitant use of a metal coagulant.
2. The benefit which can be ascribed to the use of Anionic *A* is a greatly increased size of floc, which produces an increased rate of settling.
3. It has not been shown in the laboratory tests that either the coagulant dose or the flocculation time can be substantially reduced without some sacrifice of final water quality.
4. For some waters the effective range of concentration of Anionic *A* is limited. Doses exceeding this concentration produce a dispersion rather than a coagulation.
5. The activity of Anionic *A* appears to be independent of physical and chemical water characteristics, such as pH, alkalinity, hardness, and turbidity; the only requisite is that a floc be produced by a metal coagulant.

Cationic *B*

Preliminary work with Cationic *B* was done with the laboratory-prepared water used for the study of Anionic *A*. It was quickly discovered that benefits from the use of Cationic *B* could not be obtained with this water. Further work disclosed that Cationic *B* had no effect on coagulation when mineralization was low or absent. This behavior was proved experimentally with a test water prepared by suspending the clay, used in the preparation of synthetic turbid water, in Cincinnati tap water.

Addition of Cationic *B* to an alum coagulation of this water gave increased settling rates as shown in Fig. 2. When this test water was diluted with an equal amount of distilled water, which produced a slightly mineralized water containing about 20 mg/l of alkalinity, however, no benefits were obtained, demonstrating that dissolved substances and not the suspended clay particles are responsible for the lack of activity.

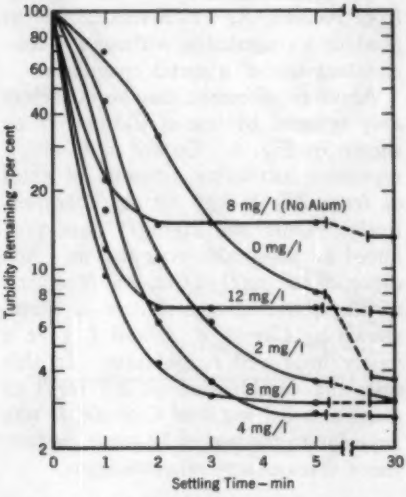

Fig. 3. Effect of Cationic *B* on Ohio River Water

Cationic B was added to Ohio River water in amounts shown; all except one contained 20 mg/l alum.

Cincinnati Tap Water

Since lack of activity in the unmineralized water precluded use of the standard synthetic turbid water, Cincinnati tap water with added clay turbidity was used in the first phase of the investigation. Again, as with the natural waters studied, 25–30 gal of this water were collected at one time to insure a uniform supply. Chemical characteristics of two batches of test water were: pH, 7.9–8.6; alkalinity, 35–43 mg/l; hardness, 112–152 mg/l; and added turbidity 105–113 units.

The time of addition and the concentration of Cationic *B* to obtain maximum results were studied in detail. Although some increases in settling rate were obtained when Cationic *B* was added before or simultaneously with alum, best results occurred when additions were made 1–8 min after the addition of alum.

Shown in Fig. 2 are the settling rates for varying concentrations of Cationic *B* when added 1 min after the addition of 10 mg/l of alum. Maximum benefits were obtained over a relatively narrow range of concentration. Good coagulations (high settling rate plus low residual turbidity) resulted with 1–4 mg/l of Cationic *B*. Increased doses, of 6–8 mg/l, yielded increased residual turbidities, indicating interference with efficient clarification.

Further work with this water showed that increased amounts of Cationic *B* were required as the alum dose was raised. Some reduction in flocculation time could also be obtained by addition of Cationic *B*. Thus, a satisfactory effluent was achieved in 20 min with Cationic *B*, where 30 min were required with alum alone. Cationic *B* was fully effective with ferric sulfate coagulation.

Ohio River Water

Chemical characteristics of Ohio River water were: pH, 7.5; alkalinity, 61 mg/l; hardness, 141 mg/l; and turbidity, 98 units. In experiments with this water, greatly accelerated settling rates were obtained when Cationic *B* was added before, simultane-

ously with, and 1–5 min after the alum coagulant addition. Best results, however, were invariably produced when Cationic *B* was added 1 min after the alum when the alum floc was barely visible. Optimum concentration of Cationic *B* was determined by adding increasing amounts of the polyelectrolyte 1 min after the addition of 20 mg/l of alum. These data are summarized in Fig. 3.

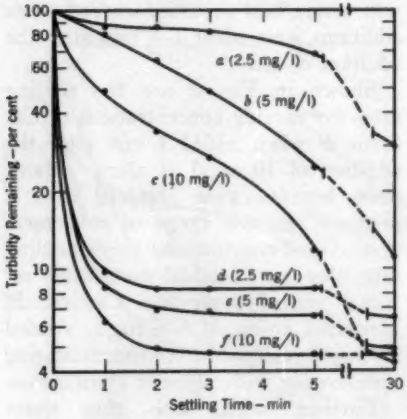

Fig. 4. Reduction of Alum Requirement by Use of Cationic *B*

Curves* a, b, *and* c *represent solutions with no Cationic* B*; Curves* d, e, *and* f, *solutions with 8 mg/l Cationic* B. *Alum concentrations are designated in amounts shown.

In Fig. 3, the doses of 4 and 8 mg/l of Cationic *B*, respectively, show the highest settling rates and low residual turbidity. Increasing the concentration of Cationic *B* to 12 mg/l gives a settling rate initially rapid but with clarification incomplete, resulting in an excessive residual turbidity. Clearly, addition of amounts of Cationic *B* in excess of the optimum dose results in an interference with coagulation. This behavior demonstrates the "schizophrenic" nature of polyelectrolytes in general, namely a small concentration range useful for flocculation and a somewhat higher range in which the polyelectrolyte behaves as a dispersant.

The zero-alum curve in Fig. 3 represents a coagulation obtained by adding 8 mg/l of Cationic *B* without additional coagulant, producing an effluent which would probably be suitable for application onto a sand filter. In this respect, Cationic B differs markedly from Anionic A, which was unable to produce a coagulation without the concomitant use of a metal coagulant.

Alum requirement can be considerably reduced by use of Cationic *B* as shown in Fig. 4. Curves *a*, *b*, and *c* represent increasing amounts of alum of from 2.5, 5, and 10 mg/l, respectively. Only the 10-mg/l dose produced an acceptable coagulation. Addition of 8.0 mg/l of Cationic *B* to each of the above concentrations of alum, shown as Curves *d*, *e*, and *f*, gave a vastly improved coagulation. In this test, the combination of 2.5 mg/l of alum and 8.0 mg/l of Cationic *B* was superior to the use of 10 mg/l, or four times the amount, of alum alone.

Further Effects

In the preceding discussion of the experimental behavior of Cationic *B* alone and in conjunction with alum, the principal benefits are derived fundamentally from the effect of Cationic *B* on clay and metal coagulant particles. Because Cationic *B* is a cationic polyelectrolyte, it was presumed that its effect on specific substances would be a promising area for investigation. Accordingly, several materials were studied briefly in order to define some additional areas of usefulness for a cationic polyelectrolyte.

Sodium tripolyphosphate. A major ingredient of synthetic detergents are the polyphosphates, of which sodium tripolyphosphate is the most important. Previous studies in this laboratory (*9*) and in work reported by Howells and Sawyer (*10*) have shown that small amounts of this material caused interference and even complete inhibition of alum coagulation. The effect of Cationic *B* on alum coagulation of water containing sodium tripolyphosphate was determined in the following experiment:

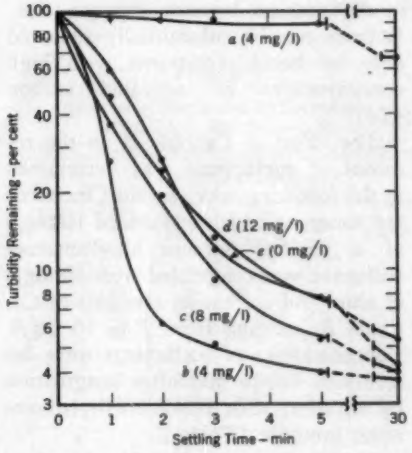

Fig. 5. Effect of Cationic *B* on Interference of Sodium

Solutions represented by Curves a *and* e *contained no Cationic* B*; the other three contained 4 mg/l. Sodium tripolyphosphate was added in amounts shown.*

A sufficient concentration of sodium tripolyphosphate was chosen to produce complete interference with alum coagulation. Using Cincinnati tap water with added clay turbidity as test water, 4 mg/l of sodium tripolyphosphate completely prevented coagulation with 10 mg/l of alum (Curve *a*, Fig. 5). A series of jar tests was then made in which test water containing increasing amounts of sodium tripolyphosphate was coagulated with 10 mg/l of alum and 4 mg/l of Cationic *B*. The results, shown as Curves *b*, *c*, and *d*, demonstrate that interference was eliminated even in the presence of up to 12 mg/l of sodium tripolyphosphate. In effect, tolerance for this troublesome material had been increased by a factor of at least three. No attempt was made to determine the maximum amount of sodium tripolyphosphate which could be tolerated by the addition of 4 mg/l of Cationic *B*.

A similar experiment with Anionic *A* as a coagulant aid showed that interference with coagulation by sodium tripolyphosphate could not be reduced. Superior coagulation was obtained only when sufficient alum had been added to obtain a floc. The prior presence of an alum floc was a requisite for the benefits obtainable from Anionic *A*.

Lignin compound. Lignin compounds in water supplies not only produce colors that are difficult to remove, but they are also difficult to treat by coagulation. Greatly increased amounts of alum are required when lignin compounds are present and floc produced under these conditions is fine and slow settling (*11*).

To check the effect of Cationic *B* on an alum coagulation in the presence of lignin compound, an experiment similar to the one for sodium tripolyphosphate was set up. In this test 7 mg/l of a sodium lignosulfonate * seriously inhibited coagulation with 15 mg/l of alum in turbid Cincinnati tap water. The result, shown as Curve *a* in Fig. 6,

* "Orzan S," a product of Crown Zellerbach Corp., Camas, Wash.

clearly indicated that no appreciable clarification was obtained. Addition of 5 mg/l of Cationic *B* produced an excellent coagulation as demonstrated in Curve *b*. Curves *c*, *d*, and *e* represent the settling rates obtained in the presence of increasing amounts of the lignin compound. Settling rate was

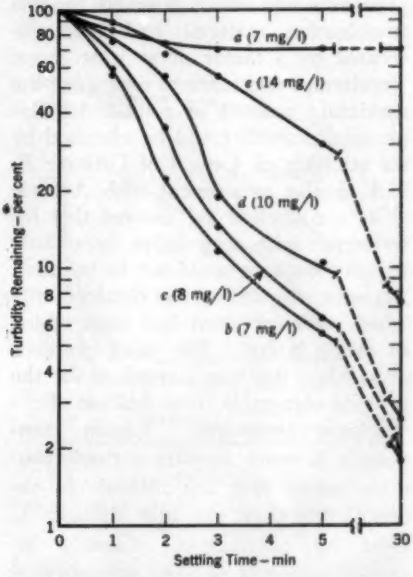

Fig 6. Effect of Cationic *B* on Interference of Lignin Compound

All solutions contained 15 mg/l alum; all except the one represented by Curve a, *5 mg/l Cationic* B. *Lignin compound was added in amounts shown.*

decreased as concentration of the compound increased, but in all tests, a very satisfactory coagulation was obtained. It is abundantly clear from this experiment that tolerance for a lignin compound is increased by a factor of at least two when coagulation is aided by Cationic *B*.

Synthetic detergents. Effects of the various components of synthetic detergents on the chemical coagulation of water have been studied in this laboratory (*9*) and by Howells and Sawyer (*10*). Results indicate that the surfactant portion does not interfere with coagulation, but that normal coagulation does not remove significant amounts of the surfactant. Concentrations of the surfactant in the finished water are only 5–10 per cent less than in the untreated water supply. Surfactants can be substantially removed only by heroic treatment with high concentrations of activated carbon (*12*).

The effect of Cationic *B* on the removal of surfactants was determined in the following way: turbid Cincinnati tap water, to which was added 10 mg/l of a purified sodium alkylbenzenesulfonate, was coagulated with 10 mg/l of alum and increasing amounts of Cationic *B*, ranging from 2 to 16 mg/l. Concentrations of surfactants were determined before and after coagulation by titration with cetyltrimethylammonium bromide (Table 2).

The control test, No. 1, with alum alone, produced the expected 6 per cent removal of surfactant. Increasing amounts of surfactant, up to 45 per cent, were removed as the concentration of Cationic *B* was increased.

Removal of the surfactant by Cationic *B* is apparently an adsorption phenomenon. When the data are plotted according to the Freundlich adsorption equation, a linear relationship is found between the surfactant removal and the Cationic *B* application.

Algae. Ives (*13*) has recently performed electrophoretic experiments which demonstrated that algae and plankton in general carry electrical charges similar to colloidal nonliving

particles. All the algae investigated were electronegative at all pH values. Ives also concluded that the basic mechanism of algae flocculation by chemical coagulants is one of mutual attraction and charge neutralization of electronegative algae with positive hydroxide floc.

One of the inherent properties of polyelectrolytes in general is an unusually large charge density, which results from the recurring, closely situated ionized sites on the polymer. It was anticipated, therefore, that Cationic *B* would be an effective coagulant for electronegative algae. That this is indeed true was shown in the following experiment:

TABLE 2

Removal of Surfactant by Coagulation With Alum and Cationic B

Test	Alum *mg/l*	Cationic B *mg/l*	Surfactant–*mg/l*		Percentage Removed
			Before Coagulation	After Coagulation	
1	10	0	9.8	9.2	6
2	10	2	9.8	8.6	12
3	10	4	9.8	8.0	18
4	10	8	9.8	6.8	31
5	10	12	9.8	6.0	39
6	10	16	9.8	5.4	45

A unialgal culture of *Chlorella* was inoculated into a modified Gerloff's medium (*14*) and incubated until a heavy growth of algae was obtained. Separate aliquots of this culture were treated with increasing amounts of Cationic *B* by stirring for 1 hr and then by standing for 1 hr. Samples of the supernatant were then withdrawn for microscopic enumeration. Results obtained in this experiment are shown in Table 3.

Addition of up to 40 mg/l of Cationic *B* showed no coagulation. With 80 mg/l a visible floc was formed which settled within 5 min. Microscopic count, however, showed only an 80 per cent reduction in numbers of algae in the supernatant. The succeeding concentrations of Cationic *B* all produced a large, rapidly settling floc which yielded a clear effluent with reductions in numbers of algal cells amounting to 99.7–99.8 per cent. Microscopic observation revealed that practically all *Chlorella* cells were agglomerated.

TABLE 3

Coagulation of Chlorella *by Cationic* B*

Samples	Cationic *B* *mg/l*	Cells *ml*	Reduction *per cent*
1	0	8,000,000	—
2	0†	8,000,000	0
3	40	8,000,000	0
4	80	1,500,000	81.0
5	120	25,000	99.7
6	160	25,000	99.7
7	200	20,000	99.8

* Causticity of the Cationic *B* solution was neutralized with dilute sulfuric acid just prior to addition to the coagulation.

† This sample was stirred for 1 hr and allowed to stand for 1 hr, with no apparent settling of algae.

This experiment was repeated with Anionic *A* as a coagulant. The fact that no coagulation was obtained would indicate that charge neutralization by a cationic substance is a requisite for agglomeration of the negatively charged algal cells.

Summary

The experimental evidence shows that Cationic *B* is a polyelectrolyte obviously different from Anionic *A*. The difference in charge, cationic as opposed to anionic, endows Cationic *B* with certain behavior of which Anionic *A* is incapable:

1. In addition to its activity as a coagulant aid, Cationic *B* can perform as a true coagulant when the suspended particles are negatively charged.

2. Because of its positive charge, suitable negative ions in solution can be effectively precipitated or complexed. Thus, the interference of sodium tripolyphosphate and lignin compounds with alum coagulation is masked by Cationic *B*. Further evidence that a positive-negative organic salt is formed is demonstrated by the removal from solution of a dissolved substance such as sodium alkylbenzenesulfonate.

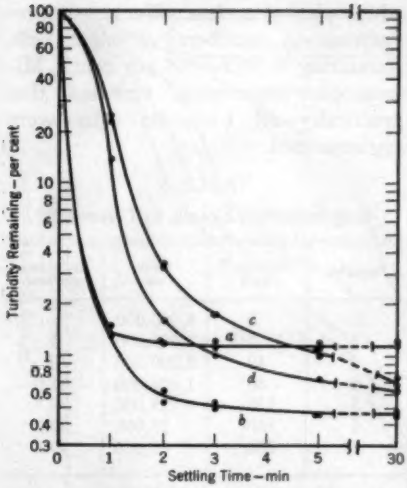

Fig. 7. Effect of Coagulant Aids on Ohio River Water

Ohio River water was used, with 40 mg/l alum added to each test. Curves, each one an average of duplicate tests, represent coagulations made with aids added in optimum amounts, as follows: a, *1 mg/l Anionic* A; b, *6 mg/l Cationic* B; c, *20 mg/l Nonionic* C; *and* d, *alum alone.*

3. The ability to coagulate living organisms, such as certain algae, provides Cationic *B* with an advantage lacking in Anionic *A*.

4. Cationic *B* is inactive in demineralized or slightly mineralized water, a situation which may have practical importance in some areas of the country where surface waters are generally low in mineralization.

Nonionic C

Initial work with Nonionic *C* in laboratory-prepared water encountered the same difficulties as with Cationic *B*. Concentrations of Nonionic *C*, ranging from 0.05 to 2.0 mg/l, were added both before and after alum addition without any effect on the quality of coagulation. Work with this test water was then abandoned.

Further evaluations of Nonionic *C* were attempted using a semisynthetic prepared water, with clay turbidity added to Cincinnati tap water. Additions of 0.05–0.5 mg/l of Nonionic *C* to this water actually decreased the quality of alum coagulation. Concentrations of 1–2 mg/l completely prevented coagulation.

Lack of activity of Nonionic *C* in both synthetic turbid water and turbid Cincinnati tap water prevented further study of the variables affecting the use of this aid in these waters.

Ohio River Water

A series of coagulations was then made using Ohio River water with alum and with concentrations of Nonionic *C*, ranging from 0.05 to 2 mg/l, added before and 1–5 min after the alum. Again, no significant improvement was obtained over the control coagulation. Quality of the coagulation actually decreased with the higher concentrations. Decreased settling rates and high residual turbidities were also obtained. Characteristics of this water

were: pH, 7.6; alkalinity, 84 mg/l; hardness, 132 mg/l; and turbidity, 1,000 units.

To prove that this water possessed no exceptional characteristics which made it resistant to coagulant aids, a series of coagulations was made using all three coagulant aids with alum. Each aid was used at its optimum concentration and optimum time of addition (Fig. 7). Each curve is an average of duplicate coagulations. Good coagulations, Curve *d*, were obtained with 40 mg/l of alum. Addition of 20 mg/l of Nonionic *C* (Curve *c*), was, in fact, slightly detrimental to coagulation. Both Anionic *A* and Cationic *B* (Curve *a*, *b*) produced a rapidly settling floc. Coagulation aided by Cationic *B* was superior in that residual turbidity was lowest. Slightly increased residual turbidity appears to be characteristic of coagulations aided by Anionic *A*.

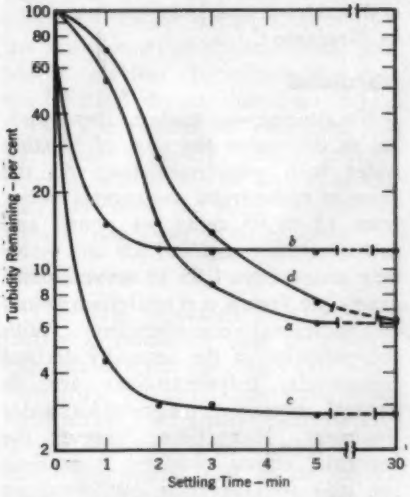

Fig. 8. Effect of Coagulant Aids on Pond Water

Each solution contained 30 mg/l alum. Curves represent coagulations obtained with: a, *alum alone;* b, *0.5 mg/l Anionic* A; c, *2 mg/l Cationic* B; *and* d, *2 mg/l Nonionic* C.

Pond Water

A pond water of somewhat different mineral and turbidity characteristics—pH, 7.4; alkalinity, 36 mg/l; hardness, 55 mg/l; turbidity, 300 units—was then studied for the effect of Nonionic *C* on an alum coagulation. Here, too, as with Ohio River water, no demonstrable benefits could be obtained with concentrations of Nonionic *C* ranging from 2 to 20 mg/l. Varying the time of addition made no difference in the results.

This water was then subjected to a comparative study similar to that for Ohio River water. These data, plotted in Fig. 8, again reveal that effective coagulation may be obtained only if the right type of polyelectrolyte is used. In this test series, Cationic *B* produces the best coagulations. Anionic *A*, which produced a large, rapidly settling floc, failed, however, fully to clarify the water. Nonionic *C* produced a slightly less efficient coagulation than the control. All coagulations shown would be acceptable for application to a sand filter; however, if a rapidly settling floc and fully clarified water were required, alum coagulation aided by Cationic *B* would be the choice.

Virgin River, Nev.

As pointed out above, all polyelectrolytes are not equally effective in all waters; hence empirical methods must be used for each water. It has been shown thus far that Nonionic *C* is ineffective as a coagulant aid with some waters. That it does provide some

benefits with certain waters was shown with a sample of water from the Virgin River, Nev. Characteristics of this water were: pH, 7.6; alkalinity, 280 mg/l; hardness, 900 mg/l; and turbidity, 2,700 units. The results obtained by treating this highly mineralized water with alum and with increasing amounts of Nonionic *C* are shown in Fig. 9.

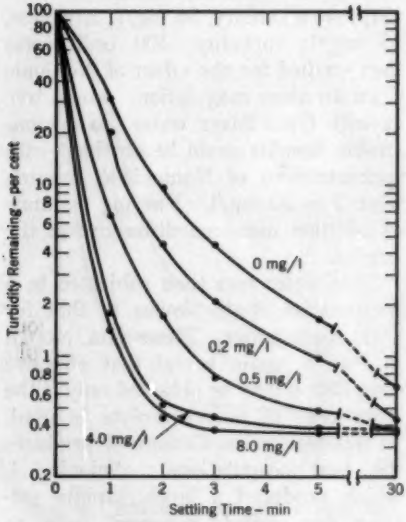

Fig. 9. Effect of Nonionic *C* on Virgin River Water

Tests were made with the highly mineralized water of the Virgin River (Nevada). Nonionic C was added in amounts shown; all solutions contained 30 mg/l alum.

In this series of coagulations, all of the concentrations of Nonionic *C* tested, from 0.2 to 8.0 mg/l, improved coagulation with alum by increasing the settling rate of alum floc. The optimum concentration of Nonionic *C* was found to be 4.0 mg/l. Increasing the concentration to 8.0 mg/l yielded only a slight increase in the settling rate.

Summary

The naturally derived polyelectrolyte, Nonionic *C*, has been shown to be considerably less effective or versatile as a coagulant aid than either Anionic *A* or Cationic *B*. Among the several waters tested, only one was aided by Nonionic *C*.

Discussion

No attempt was made in these studies to determine the cost of treating water with polyelectrolytes. As the price of commercial compounds varies from 15 to 95 cents per pound and as the amount required for any water may range from 0.05 to several milligrams per liter, a cost analysis becomes an individual consideration. With the exception of the naturally derived compounds, polyelectrolytes are, in general, expensive reagents for water treatment. Many times, however, the beneficial effects obtained from their use may well override considerations of cost. Treatment with polyelectrolytes may be justified when the alum dose is substantially reduced by the addition of small amounts of a coagulant aid, during temporary periods of coagulation difficulty, and when increased volumes of water must be produced in an inadequate physical plant. It should also be emphasized that the concentrations of polyelectrolytes used in laboratory experimental work probably are high, especially since the doses represent the concentrations needed to give maximum settling rates. In actual practice, however, lesser amounts could be used with only slightly lower settling rates. The cost,

then, of treating water with polyelectrolytes must be determined at the water plant.

Since polyelectrolyte compounds are being proposed for use in municipal water supplies, the question of toxicity must be examined. In fact, the toxicity aspect, up to this time, has been one of the deterrents to their wider acceptance and use. Polyelectrolytes will surely be widely employed once their use is approved by the individual state health agencies. To achieve this goal, the USPHS has established a technical advisory committee on coagulant aids for water treatment, whose primary function is to review all aspects of toxicity concerning the use of polyelectrolytes in municipal water supplies.*

Conclusions

The data presented in this paper clearly demonstrate that polyelectrolytes are effective coagulant aids which may prove useful in some water treatment plants. As a polyelectrolyte may be one of a very large number of different compounds and as no natural waters are entirely alike, it becomes difficult to generalize on the behavior of these aids. Under the right conditions of use with the right test water, however, some or all of the following benefits may be obtained:

1. When used in conjunction with common metal coagulants, polyelectrolytes yield large, dense floc which settles rapidly. Clarification is also frequently improved.

2. Since floc rapidly attains settleable size, flocculation time may be reduced.

3. With some waters, reduction in dose of the metal coagulant has been found feasible when small additions of polyelectrolyte are made.

4. Certain polyelectrolytes, especially the cationic type, aid in coagulation of water which contains interfering materials. Thus, good coagulations are obtained with minimum amounts of alum, even in the presence of such dispersants as lignin and sodium tripolyphosphate.

5. Cationic polyelectrolytes aid in the removal from solution of an alkylbenzenesulfonate by alum coagulation.

6. Algae are rapidly and completely coagulated by cationic polyelectrolytes.

7. With some waters, coagulation may be obtained with the addition of a polyelectrolyte without the conjoint use of a metal coagulant. For those waters, then, polyelectrolytes are coagulants in their own right in addition to being coagulant aids.

When polyelectrolytes are used as an aid in alum coagulation, certain precautions must be observed:

1. All polyelectrolytes are not equally effective with all waters. This variation requires that each water be individually examined to find its most effective polyelectrolyte.

2. Maximum benefits from polyelectrolytes are obtained within a relatively narrow range of concentration. Doses of a polyelectrolyte in excess of the optimum frequently yield an undesirable coagulation by causing either dispersion or incomplete clarification.

3. The point of addition of a polyelectrolyte to an alum coagulation must be determined for each water. The time of addition may vary from any time before to several minutes after the addition of alum.

* The USPHS committee has issued its first report, which approves certain coagulant aids (see this issue, p. 462). The work of the committee is continuing.—Ed.

4. Polyelectrolytes are best added as a very dilute solution to ensure thorough mixing.

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Method for Automatic Control of Coagulant Dosage

Arthur M. Buswell

A contribution to the Journal by Arthur M. Buswell, Research Prof. of Chemistry, Univ. of Florida, Gainesville, Fla. *The study described is being supported by Research Grant RG-4516 from the National Institutes of Health, USPHS, Washington, D.C.*

PRELIMINARY studies have been directed toward determining whether it would be possible to control chemical dosage in water treatment by means of coordinated centrifuges and photometers adjusted to monitor the raw and treated water and regulate the chemical feed.

Since it appeared that such a setup might be patentable or involve patentable features, the investigators were required by the terms of the grant to report it to the National Institutes of Health for determination as to which of various procedures should be followed in making the results available to the public. This requirement was complied with, and publication of the results received approval.

In a recent paper discussing the jar test (*1*) for regulating alum dosages, it was pointed out that one of the problems encountered in this procedure was the early determination of the turbidity between the flocs. The same problem is encounterd in trying to follow the progress of purification through the various steps in an operating plant. Various solutions of this problem were described. The preferred procedure appeared to be to strain the reacting mixture through cotton or metal gauze for floc removal and then to determine residual turbidity in the usual manner. Such procedures are subject to question, since any filtering or straining procedure may remove substantial amounts of turbidity above that which has been taken up by the floc. If the floc is allowed to settle, as in a plant sedimentation basin, 1 hr or more must elapse before a sample can be taken.

Centrifugal Force

A review of other possible methods suggested that if sedimentation could be accelerated by centrifugal force, it might be possible to obtain a suitable sample which would be comparable to one obtained after gravity sedimentation for a longer time.

For the success of such a method it would be necessary to apply a centrifuge speed, or g (gravity) value, large enough to remove the floc but small enough so that the uncoagulated turbidity would not be detectably removed within the time of application. Experiments carried out by the author some years ago indicated that turbidity was removed without addition of coagulants at the lowest speed attainable with the laboratory centrifuges then available. Repetition of such experiments in the present study with a centrifuge confirmed the earlier results, although some evidence of floc separation was observed.

Another centrifuge, with variable-speed attachment and tachometer, was

next obtained and used to study further the effect of low g values on turbid samples, both with and without added coagulant.

With this equipment, tests were run on a bentonite suspension, with and without the addition of alum. These tests showed that at centrifuge speeds giving less than 200 g, turbidity is not removed within limits detectable by the spectrophotometer and under the sampling procedure used while the floc is removed at such a low centrifugal force. It appears possible, therefore, to separate the floc from partially coagulated water, without the errors due to straining and filtering, and thus obtain a sample of the suspension between the floc for turbidity measurement.

Application

A possible setup to apply the above principle to plant control would be the following. Two separate streams, A and B, of raw water would be provided. Stream A would pass through a photometer, while Stream B would pass through a variable-speed centrifuge and then through a second photometer maintained in check with the first photometer. The rate of the centrifuge would be automatically controlled so that the two photometers would read the same. That is, the centrifuge would be adjusted to a speed such that it would remove no turbidity. This centrifuge would then act as a master centrifuge, controlling the rates of other centrifuges as required. Specifically, a secondary centrifuge, or centrifuges, operating at the control rate would receive a sample stream or streams from appropriate points in the treatment process, such as the effluent from the mixing basin. A secondary photometer would report the effect of the coagulant at this point and activate automatic adjustment of the chemical feed mechanism as determined by the previous setting.

Use of this principle with the jar test might be accomplished with a single centrifuge and photometer. The speed of the centrifuge which would not reduce the transmittancy of the raw-water sample would be determined, and that speed would be used to remove the floc from the sample on which the effect of various dosages and times used in the jar test would be determined.

Conclusion

A check of catalogs and manufacturers indicated that a suitable centrifuge and other accessory equipment for further development of this method to evaluate the effect of coagulants were not available. The official investigators in charge of the project realized that a large amount of development work along the line of instrumentation would be required to construct a workable automatic-control unit. Such development work did not appear to be within the purpose of the grant. It was decided, therefore, on the advice of the USPHS, to submit this report, with a description of its implied application, for publication. Thus, the material is made available to the public. Anyone who may consider it of merit and desire to develop it further may do so, but it should be understood that because of limitations in instrumentation, the data are not to be regarded as precise. It is felt, however, that they warrant the conclusions as qualified in this report.

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Control of Earthy, Musty Odors in Water by Treatment With Residual Copper

Kent A. Bartholomew

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by Kent A. Bartholomew, Biologist, Dept. of Water & Power, Los Angeles, Calif.

CONTROL of earthy, musty odors that had characterized the Los Angeles aqueduct water supply for many years was first accomplished in 1950. It was one of several secondary benefits of treatment with residual copper.

The primary purpose of the residual-copper treatment had been to control copper-sensitive pond weeds and reduce plankton populations in the water. It had been found by previous experience that a relatively low, constant, copper residual was more toxic to these submerged growths than were intermittent heavy treatments. This effect resulted from the fact that copper remains active—either in solution or suspension—for longer periods of time than had previously been suspected. In the Los Angeles aqueduct water, which has an average hardness of 84, a pH of 8.28, and alkalinity of 116, the copper remained toxic to plants for many weeks.

Treatment in 1950

Residual-copper treatment began in the Los Angeles Aqueduct at Dry Canyon Reservoir, 40 mi north of Los Angeles in April 1950 (*1*). The copper residual was maintained in the water by a constant-feed copper sulfate solution tank, from which a saturated copper sulfate solution was regulated to give a predetermined copper concentration in the water. Distribution of the copper was dependent upon the flow of the water in the aqueduct and the circulation patterns in the reservoirs.

The copper sulfate residual in Dry Canyon was kept at 0.8–0.9 ppm (approximately 0.2 ppm copper) for the first three months, and adjusted to 0.6 ppm (0.15 ppm copper) for the rest of the season. The copper residual passed quickly through Dry Canyon reservoir and down the aqueduct to the city reservoirs—the Upper and Lower San Fernando (now renamed Upper and Lower Van Norman) reservoirs. As the copper residual built up in these reservoirs, the earthy, musty odors in the water leaving the lower reservoir became noticeably less. Experience had shown that copper and the usual chlorination procedures have little effect on these odors. It was assumed, therefore, that the copper residual was toxic to some odor-producing mechanism in the reservoir.

In October, at the close of the 1950 season, the treatment had consumed 165 tons of copper at a cost of $25,000. The combined benefits of the treatment, however, more than justified the cost. The treatment has, therefore, been continued for the past 7 years with equally gratifying results.

Lower Hollywood Reservoir—1953

The second experience in which a copper residual was found to control earthy, musty odors occurred in Lower Hollywood Reservoir, one of the terminal reservoirs in the aqueduct system. It lies in Weid Canyon above the Hollywood business district in the Santa Monica hills. Most of its water is supplied by the aqueduct system, although during the summer the aqueduct supply is supplemented by San Fernando Valley well water. The well water dilutes the copper residual in the reservoir, making it possible for extensive plankton growths to develop. In the late summer and fall a stagnant stratum of water in the bottom of the Lower Hollywood Reservoir is gradually absorbed into the upper circulating zone, or epilimnion, by the cooling of the upper circulating waters. Materials liberated from this anaerobic zone and plankton accumulations furnish adequate nutrient for the development of tastes and odors.

In 1952 the odors developing in the reservoir were predominantly earthy and musty. Threshold odors as high as 20 were recorded and consumer complaints made it necessary to bypass the reservoir—partially or completely —for 31 days during the fall. In October 1952 bacterial samples were taken from the surface as well as from each of the five gate elevations. One-milliliter portions of these samples, plated on soil extract agar medium, were found to contain 50–760 *Streptomyces.** Following temperature and chemical equalization in the reservoir, the odors gradually subsided, leaving the water entirely in March 1953.

To prevent the possibility of a recurrence of the odors in 1953, a constant-feed copper sulfate solution tank was put into service at the inlet to the Lower Hollywood Reservoir. The additional copper residual was expected to reduce the overall organic load by controlling plankton growths in the reservoir. The average copper residuals in Lower Hollywood Reservoir from the Dry Canyon feed in the spring, summer, and fall of 1952 had been 0.04 ppm. In 1953 additional copper sulfate raised the copper residuals in the reservoir to 0.18 ppm. Earthy, musty odors were suppressed in the reservoir and attempts to isolate *Streptomyces* from the water were unsuccessful.

In the years since 1953, the supplementary copper sulfate treatment at the Lower Hollywood inlet has continued. It has been accompanied in the reservoir by chlorination of the stagnant bottom water. This combination has proved adequate to control the annual tastes and odors that formerly occurred in this reservoir.

Bouquet Reservoir—1955

The addition of a continuous copper residual to Bouquet Reservoir during the summer of 1955 was the first attempt to use copper sulfate for the sole purpose of controlling earthy, musty odors.

Bouquet Reservoir is a 36,500 acre-ft storage reservoir on the Los Angeles Aqueduct above Dry Canyon Reservoir. It is used to increase the flow of aqueduct water to San Francisquito Power Station penstocks when peak electric loads require more power and to replace the aqueduct supply when the northern section of the aqueduct is out of service for inspection and repairs.

* *Streptomyces:* A genus of the Order Actinomycetales B., commonly referred to as one of the *Actinomycetes* (*2*).

The reservoir has for many years had a reputation for its earthy, musty odors. Following the control of excessive odors below Dry Canyon Reservoir with residual copper treatment, earthy, musty odors in the Bouquet water became more objectionable.

In October 1954, Bouquet water was used to replace the aqueduct water while repairs were being made on the upper aqueduct system. Examination of the water in the reservoir revealed an earthy, musty threshold odor of 7. Because the aqueduct at this time was relatively free of odors, it was necessary to treat the Bouquet outlet water with 40 tons of activated carbon to reduce the odor to a more acceptable level.

The following year, Bouquet was treated periodically with copper sulfate snow distributed over the reservoir surface from a boat. A total of 40 tons of copper sulfate were used during the summer and fall. Aided by a high thermal stratification in the reservoir, copper sulfate residuals of 0.5–0.8 ppm were maintained in the epilimnion. This treatment successfully suppressed production of earthy, musty odors. It has since been determined that about half this amount of copper sulfate is adequate for odor control. In the 2 years since the 1955 treatment, 20 tons of copper sulfate have been used each season with satisfactory results.

Treatment at Haiwee—1957

Residual copper treatment at Dry Canyon and periodic copper sulfate treatments at Bouquet Reservoir gave the lower portion of the Los Angeles Aqueduct satisfactory protection against the production of earthy, musty odors. Haiwee Reservoir, however, which lies in the lower Owens Valley at the head of the closed portion of the aqueduct, still contributed typical earthy, musty odors to the water supply in September and October of each year.

The Haiwee Reservoir basin is composed of a north and south portion connected by a shallow strait. The reservoir is 7 mi long, covering 1,804 acres of land with a capacity of 58,800 acre-ft of water. The reservoir circulation is complicated by the structure of the double basin and extensive shallow areas along the central margins of the reservoir.

On Jun. 10, 1957, a constant-feed copper sulfate solution tank was put into operation at Haiwee inlet. The intended copper sulfate residual was 0.6 ppm. On Jun. 26, the copper sulfate feed was raised to 0.8 ppm. In the reservoir the copper residuals were raised quickly to effective levels by adding copper sulfate to the reservoir surface from a boat. It was necessary to continue the surface copper treatments—especially in the south basin—because of an apparent loss of copper from the water and because of an unequal distribution of copper in the reservoir.

The average copper sulfate residual at the Haiwee outlet from June to September was 0.48 ppm. Earthy, musty odors were suppressed, with none recorded in the outlet water until late in August. At this time, lowering of the reservoir brought into circulation water from the marginal shallows which was accompanied by silt washed from the banks by excessive wind action. The constant-feed copper sulfate solution tank was shut down for the season on Sep. 4 and copper residuals soon dropped in the upper aqueduct system. The earthy, musty odors returned to the upper aqueduct water but were mild compared to those of former

years. These odors were reduced by natural losses from the water and through dilution in lower reservoirs. In the fall of 1957 the odors from Haiwee were hardly noticeable in the terminal reservoirs in Los Angeles.

Bacteriological Considerations

These experiences with residual-copper treatment indicated that some biological mechanism was being altered. In many instances a constant copper residual of 0.1 ppm in the aquatic environment inhibited the production of earthy, musty odors.

In searching for the answer to this problem, the conclusion was reached that the odor was of bacterial origin. This was decided by a process of elimination: The time and intensity of the earthy, musty odors did not correlate with any of the plankton or attached growths in the aqueduct system. Molds were not found in routine or special surveys made of the water; the water and surrounding basins, however, contained sufficient quantities of organic matter to support extensive bacterial populations.

After many attempts to isolate significant numbers of bacteria that could produce odors similar to those in the water, samples from the Lower Hollywood Reservoir were found, in October 1952, to contain *Streptomyces*. The *Streptomyces* counts were not large compared to those found in the soil, but the bacteria were present at the time of intense earthy, musty odors in the reservoir and were capable of producing similar odors in the laboratory.

If it could be assumed, on the basis of these isolations, that *Streptomyces* was the agent responsible for the earthy, musty odors, then it would be expected that it must also be too sensitive to copper in relatively low concentrations. To test this possibility, a number of copper tolerance tests were run on laboratory media and on samples of raw water solidified with agar.

Laboratory Methods

In selecting a laboratory medium for testing the copper cation, a survey of the literature indicated the necessity of avoiding protein or protein derivatives in the test media (*3*).

TABLE 1

Comparison of Streptomyces *Growth in Different Media and Varying Concentrations of Two Copper Salts*

Copper ppm	Counts per Plate*		
	Ashby's Medium		Nutrient Agar
	Copper Sulfate	Copper Acetate	
0.00	38	51	86
0.025	11	62	
0.05	12	16	75
0.10	2	14	105
0.20	5	22	108
0.40	1	0	100
0.80	0	1	89
1.60			98
3.20			92

* All plates inoculated with standard spore suspension.

The test medium selected was a further modification of the Ashby medium (*4*), on which the *Streptomyces* isolates were being kept in the laboratory. Each liter of medium contained 20 g of mannitol; 0.2 g each dipotassium phosphate (K_2HPO_4), magnesium sulfate ($MgSO_4$), and NaCl; 1 g each calcium sulfate ($CaSO_4$) and calcium carbonate ($CaCO_3$); 30 g agar; and 1 liter tap water. The laboratory medium differed from the test medium in that it contained 5 g calcium carbonate instead of 1 and 0.4 per cent

sodium propionate. The sodium propionate was added to discourage molds.

The copper standard and medium were sterilized separately. Ten milliliters of the medium was pipetted into petri dishes containing sufficient copper standard solution to make up the desired concentration. On each plate of the test medium, 1 ml of a standardized *Streptomyces* spore suspension was spread over the surface of the solidified agar. Nutrient agar was also prepared and raw-water samples used in the tests were solidified in 3 per cent agar.

Copper Tolerance Tests

Three sets of test media were used. Two sets contained copper (0.025–0.8 ppm) in the modified Ashby's test medium using copper sulfate as the copper source in one and copper acetate as the source in the other. The third set of copper concentrations (0.05–3.2 ppm) was prepared in nutrient agar using copper sulfate as the copper source.

Table 1 clearly shows the sensitivity of *Streptomyces* to copper in the unprotected synthetic medium and its ability to grow unharmed in the high-protein medium. The inorganic salt of copper used in this test was slightly more toxic than was the organic copper salt.

Copper tolerance tests were run on three raw-water samples solidified with agar (Table 2). The procedure was identical with the first test except that higher copper concentrations were tested.

The *Streptomyces* growing on the raw-water samples were surprisingly resistant to the copper. In the lower concentrations they appeared to be stimulated and hardy colonies developed in the presence of 1.6 ppm copper. The colony counts do not show the effect of copper on colony size, however. In the higher copper concentrations, colony size became progressively smaller with each increase in copper. After 30 days incubation, all colonies showing white aerial mycelium were counted—regardless of size.

In the laboratory copper tolerance tests, the free residual copper was probably reduced by combination with chemical components in the media so that the effective copper residuals would be actually lower than those indicated.

TABLE 2

Streptomyces *Growth in Increasing Concentrations Using Three Raw Waters as Media*

Copper *ppm*	Counts per Plate		
	Inoculum A*		Inoculum B*
	Well Water†	Bouquet Reservoir Water	Owens Valley Water
0.00	91	79	69
0.05	86	91	55
0.10	99	93	54
0.20	121	126	31
0.40	144	96	37
0.80	95	84	50
1.60	0	97	62
3.20	1	0	0
6.40	0	0	0

* Spore suspensions.
† From San Fernando Valley.

Discussion

The isolation of *Streptomyces* and its implication as an odor-producing agent has been pointed out by a number of workers (*5–8*). In most instances, the bacteria were found localized in a nutrient area from which they were able to elaborate their odor compounds. The *Streptomyces* isolated from the Lower Hollywood Reservoir were not typical in this respect for

they were distributed throughout the circulating water. This distribution may have been made possible by the gradual release of nutrients from the stagnant bottom water.

In the past few years, the toxicity of copper to bacteria has been closely linked to mechanisms already revealed by Fildes (*9*) for mercury. He demonstrated the loss of free sulfhydryl (-SH) groups on amino acids and similar molecules in the presence of mercury. Thimann (*10*) has grouped a number of metal ions together with mercury as sulfhydryl poisons. They include silver, mercury, arsenic, antimoney, copper, cadmium, and lead. Their toxic action is derived from their ability to react with the active sulfhydral group on a number of important enzymes. Thimann states that the effect of copper on bacteria is usually to inhibit growth rather than kill cells. This may explain the ability of a constant copper residual to suppress the development of earthy, musty odors in water when single treatments have not been noticed to effect odor production. It may also explain the quick return of the odors to water following the removal of copper from the environment.

Conclusions

The use of a copper residual to control earthy, musty odors in water supplies has been supported by a number of practical experiences in the field. *Streptomyces* satisfies several of the requirements of earthy, musty odor-producing agents in water. These experiences and laboratory findings are compatible with recent findings on the toxicity of copper to bacteria.

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Discussion

J. K. G. Silvey

Chairman, Div. of Science, North Texas State College, Denton, Tex.

During the past 10 years, the Water Research Laboratory at North Texas State College at Denton has accumulated a type collection of aquatic actinomycetes, a part of which has come from interested individuals throughout the country. In July 1953, D. W. Graham, of the Los Angeles Depart-

ment of Water and Power sent samples of organisms that had been isolated from Los Angeles raw water. After cultivation and further isolation, the collection numbers N.T. 42, 43, 44, and 45 were assigned to the four strains received. These forms are slow growers, rather difficult to cultivate, poor sporulators, and require some available nitrogen in order to give rise to musty, earthy, or woody odors. They have been included in the regular series and, during the past 2 years, have been studied together with other varieties of aquatic forms from the standpoint of morphology, taxonomy, and nutrient requirements.

The aquatic actinomycetes differ from the terrestrial forms in certain essential nutrient requirements. It appears that in order for ample growth to occur, the secondary stages of these aquatic forms must have available oxygen, temperatures of 50°–90° F, a source of organic carbon, potassium, and some form of inorganic or organic nitrogen. Although calcium, sodium, and magnesium in certain instances stimulate a few of the species, they are not essential for the growth of all forms. For example, concentrations of 10 ppm calcium appear to be as effective as 1,000 ppm in inducing growth. The same may be said concerning sodium and magnesium. Potassium, on the other hand, is a highly effective cation; minimal amounts of 2–4 ppm appear to be necessary for the development of these organisms and, as the potassium content increases, the luxuriousness of the growth appears quite evident. The sources of organic carbon are varied. These forms will grow on dextrose, lactose, sucrose, or many of the other carbohydrates, although they appear to metabolize more readily maltose or levulose. In regard to the types of nitrogen available for actinomycete production, most of the species are able to metabolize ammonia or nitrate—ammonia appearing to be the favorable compound for rapid growth. Nutritional investigations indicate that an absence of all forms of nitrogen reduces the development of the secondary mycelium. In the normal life history of the aquatic forms the primary stages are submerged, growing in company with various types of planktonic organisms or organic matter relatively rich in nitrogen. The primary stages are not responsible for many of the offensive odors that are sources of complaint from the consumer. The mild odors, such as fishy, grassy, marshy, and potato bin may be evident from time to time as a result of the growth of these stages. The secondary stages appear to be more elaborate in their requirements and in the types of odor compounds they produce. The higher the concentration of inorganic or organic nitrogen, the more profuse the growth—as long as potassium and organic carbon are available. Most of the secondary stages in the life history of the aquatic actinomycetes require some type of substrate on which to grow so that the aerial mycelia will not be completely submerged. As it happens, the varieties discussed differ from the other aquatic actinomycetes in that they do not require a substrate on which to grow and do not become exposed to the air at the time they mature. These are the only forms that have been studied at Denton that may develop the secondary stages in a submerged condition. Other species are found growing profusely on the perimeter of a reservoir, resting either on soil or on algae accumulated by continuous wind action.

Before November 1956—the date when information was received from K. A. Bartholomew on his recent study of treatment with residual copper—copper in agar had been employed as a means of isolating the aquatic actinomycetes. It had been shown (*1*) that copper was stimulating to the growth of the aquatic forms and expedited their isolation. The effect of ionized copper in a liquid medium had not been investigated. The agar employed had a fairly high protein content and, as shown in the paper under discussion, there was a stimulating effect on the growth of all types of aquatic actinomycetes.

In recent nutritional studies the writer investigated the effects of copper in a liquid medium. It was observed that in the complete absence of inorganic and organic nitrogen copper was effective in reducing the growth of certain varieties of aquatic forms—those, for example, described in the foregoing paper. The varieties, however, that require less hydration and which ordinarily produce their tastes and odors when their spores are partially exposed to the air were not affected by concentrations of copper up to 5 ppm. This group composes most of the aquatic actinomycete flora encountered in collections made throughout America.

From nutritional studies made by the writer, it can be confirmed that the poorly sporulating forms such as described by Bartholomew are susceptible to the copper ion if there is an absence of both protein and ammonia. In the presence of ammonia or nitrate in concentrations as high as 2 ppm, the copper appears to be relatively ineffective.

It is not known how the copper ion is effective in reducing the growth of one group of aquatic actinomycetes while showing a stimulating effect upon the other ten species described, nor can the reverse effect of ammonia, nitrate, or protein in small concentrations be explained. In the reservoirs cited by Batholomew, it would be very interesting if ammonia studies were done during the time of thermal stratification. In this way, the distribution of the ammonium or nitrate and organic nitrogen could be shown at the time of turnover. Apparently, the copper in those reservoirs has some effect on the nitrogen metabolism of the organism in question. Whether the nitrogenous materials are bound in some form or not, the writer is incapable of saying at this time. It is believed that this work is a contribution of value and that investigations in this area should be continued. Nutritional studies by the writer indicate that silver is much more effective than copper and that it may inhibit the growth of organisms even though the ammonium or organic nitrogen content of the water is as high as 6 ppm. In waters with higher fertility, silver appears to be ineffective. It is also proper to state that identification of the variety of actinomycete will prove of significant value since it will determine—without trial and error methods and consequent disappointing results—whether copper treatment is indicated and what effects might be anticipated.

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Development of Instrumentation in Chlorination

Robert J. Baker and Attmore E. Griffin

A paper presented on Sep. 19, 1957, at the Ohio Section Meeting, Cincinnati, Ohio, by Robert J. Baker, Chemist, and Attmore E. Griffin, Consultant, both with Wallace & Tiernan Inc., Belleville, N.J.

DURING recent years so much publicity has been given to instrumentation and automation that the idea has become widespread that these are new techniques. In the public water supply field there has always been some degree of instrumentation. A form of automation was practiced in chlorination so long ago that it is no longer regarded as new. Principles and techniques of residual recording and residual control were used over 25 years ago.

This discussion will cover instrumentation in the chlorination phase of water treatment practice and will include control of chlorination, residual determination, accessory instruments, and the extent of automation presently employed.

To trace these advances in an orderly manner, it is necessary to present two pictures: one relating to the testing procedures, the other to the mechanics of chlorine application.

Iodometric Titration

The iodometric titration—first used to measure chlorine residuals—is an accurate method but has the inherent disadvantages that the titrating and indicator solutions are relatively unstable, the test is time consuming, and only total available chlorine residuals can be measured.

Modifications of the test have been developed to make it sensitive to free available and combined available chlorine residuals but none has been particularly successful, especially in that range of chlorine residuals ordinarily encountered in water treatment practice. The iodometric titration test, ordinarily known as the starch-iodide test, is one of the standard methods used today for determining the strength of strong chlorine solutions. With this method, when the concentration of chlorine is 1.0 ppm or less, the endpoint is difficult to detect. Also, the amounts of sodium thiosulfate–titrating solution used for these amounts of chlorine are so small that large volumes of sample—1,000 ml±—must be used. It is for these reasons that this test never became popular and quickly gave way to the simpler and more dependable othotolidine test.

Orthotolidine Tests

The origin of the orthotolidine test in the work of Ellms and Hauser (*1*) and its later development by Wolman and Enslow (*2*) was a truly significant step because it put the testing for residual chlorine on a practical basis. The next step was the discovery that permanent chlorine color standards could be made in any good laboratory. This advance, in turn, led to produc-

tion by various chemical and equipment firms of chlorine test sets which used either liquid or glass standards.

The orthotolidine test, from the time of its development to the present day, is one that has been accepted by the APHA and the AWWA and has been included in late editions of *Standard Methods,* including the present 10th edition (*3*).

The orthotolidine test has been an excellent method for the purposes intended. For research work, however, and for continuous recording of chlorine residuals, the test is subject to certain errors such as color fading or false color production by certain material inherent in some waters. These factors have led to the virtual abandonment of orthotolidine as the route to follow in the development of chlorine residual recording.

Early efforts to record chlorine residuals were concentrated on the use of photoelectric cells sensitive to the color developed by orthotolidine (*4*). None was completely successful, largely because of the inherent limitations of the orthotolidine test. In one of the recording systems, it was found that the photoelectric cells could not differentiate accurately enough between the relatively small changes in yellow color which indicate the changes in residual. This, combined with awkward mechanical operation, made the system impractical. Another system, by careful control of pH, utilized the blue quinone formed by orthotolidine and chlorine because photoelectric cells were available which could more easily sense changes in the blue color (*5*). Maintenance and calibration problems, however, proved to be too great for their wide acceptance. Two of these systems, incidentally, were used to control chlorine application about 20 years ago. Other instruments using photoelectric cells for chlorine residual determination and recording were built but never proved practical.

OTA Test

Introduction of the free residual chlorination process wherein free available and combined available chlorine residuals may be present at the same time led to much research work directed toward differentiating between such residuals. Several colorimetric methods were evolved, the most practical of which used sodium arsenite in a modification of the orthotolidine test (*6*). This modification produced the ortholidine-arsenite (OTA) test which appeared in the 9th and 10th editions of *Standard Methods.* The accuracy of the OTA method is dependent to a considerable degree upon the accuracy of the original orthotolidine test. These weaknesses led to the development of the amperometric titration method (*7*).

Amperometric Titration

In the amperometric titration method, free available chlorine in water will produce a current between two properly selected electrodes immersed in water. By titrating the chlorine with a reducing agent to the point where current is no longer produced the endpoint is easily and accurately detected. This technique is called amperometric titration and instruments have been designed for its application. It is, today, the most accurate method known for determining chlorine residuals. Techniques have been developed to determine monochloramine, dichloramine, bromine, and iodine, as well as free chlorine by amperometric titration.

Recent Instrumentation

Because the current produced between the electrodes in this system is proportional to the free chlorine concentration, this same principle is used in one of the present instruments for residual recording and is the basic principle underlying much of the recent progress in chlorination instrumentation. The current produced is translated into terms of chlorine residual and recorded permanently on a chart. By controlling the pH value of the sample and by the addition of suitable reagents, either free or combined residuals may be recorded. Another system measures, in terms of residual, the amount of current necessary to reduce ferric iron to ferrous iron at a rate equal to that at which it will combine with the chlorine in a measured flow of a water sample. The potential of the reaction controls the production of ferrous iron. Only free chlorine is recorded.

Residual recording can be very useful in any water treatment plant where chlorination is employed (*8, 9*). Sudden increases in chlorine requirements may be readily detected and appropriate steps taken. For example, by establishing in the clear well a sampling point for residual recording before postchlorination, adjustments in postchlorination can be made to compensate for varying residuals caused by sunlight, changes in retention time, or undetected changes in the chlorine requirement (*10*). A recorder, sampling the plant effluent, will furnish a permanent record of the efficiency of the chlorination program. Recorders in the distribution system also yield valuable data on hydraulics of the system through comparison of chlorine residual levels.

Control of Application

Before the time that instrumentation had progressed to the stage of residual recording, improvements in chlorinators and in flow-metering equipment had made practical the control of chlorine application in proportion to the rate of flow of water and was called automatic chlorination. A constant dosage rate could be maintained without manual adjustment when flow rate changed. Chlorine feeders could also be started or stopped in synchronism with pump operation or by level controls in a basin, stand pipe, or reservoir. This was referred to as semiautomatic chlorination. Both are automatic only in the sense that a constant dosage rate of chlorine is maintained. Both are simple forms of automation.

A constant chlorine dosage rate unfortunately does not insure a constant chlorine residual. Control of the residual level is needed to eliminate the manual setting of dosage rate. When chlorine requirements fluctuate, it is extremely difficult to adjust the chlorine feeder manually to prevent periods of underchlorination or wasted chlorine. A further step in automation is achieved by using a residual recorder for direct control or by using it in conjunction with flow-metering instruments (*11*).

If the rate of flow of water to be chlorinated does not vary or if fluctuations in flow rate occur slowly, a chlorination device may be controlled directly from a residual recorder which is downstream from the chlorinator. Where flow rate changes are major or rapid, the control of the chlorine feeder dosage rate is supplanted by conventional flow control apparatus. The frequency and degree of corrective action must be controlled to prevent

the residual recorder from making excessive changes in chlorine dosage. This is done by limiting the rate of change in the control circuit.

Dechlorination

This same general arrangement of equipment may also be employed to control dechlorination. Some water utilities carry high residuals through the treatment plant to control taste and odors and then dechlorinate before the water is pumped to the system. A residual recorder may be used to control a device for feeding a dechlorinating agent. Two approaches are used; one is to dechlorinate to the desired residual level, the other is to dechlorinate completely and follow with rechlorination.

Redox Potential Method

Some industrial waste-treatment processes can be controlled by the oxidation-reduction (redox) potential. The alkaline chlorination of cyanide waste is an example (*12*). Chlorine, a strong oxidant, is added to the waste to oxidize cyanide to cyanate or to completely destroy the cyanide. The oxidation potential level is a function of the amount of chlorine needed. By controlling a chlorine feeder with a redox potential cell, a recorder, and a controller, the potential can be regulated to the desired level. This arrangement may also be used in sewage treatment to eliminate hydrogen sulfide by chlorination and to control the level of oxidation required according to the capacity of the treatment plant. This is accomplished by redox potential control of chlorination to subresidual levels (*13*). It has been suggested that the use of redox potential-controlled chlorination in iron removal plants would be advantageous in insuring an oxidizing potential level at which the iron will be in the ferric state.

Any similar application could be made where chlorination to a subresidual level or to a residual is required. Control of the amount of residual by redox potential control is not feasible with present equipment.

Although control of chlorination from the resulting residual is both feasible and practical, the fact that control of the process is based on the result means that the system is continually "hunting." There is some advantage to this as it eliminates the chance of equipment "sticking" in a fixed position. This system, however, cannot adequately compensate for both slow and rapid changes in chlorine demand.

Quality-Quantity Control

Recognizing this, instrumentation was developed for a new approach to chlorination control. The system developed measures, upstream of the chlorine feeder, the chlorine demand of the water to be chlorinated, adds to this the residual value selected by the operator, and multiplies the dosage requirement by a factor determined by the flow-measuring equipment. The dosage control equipment * is essentially a pilot chlorination plant which transmits to the chlorinator the information necessary to chlorinate water to provide either a free or total chlorine residual of a selected value. The system anticipates changes in demand —or quality—of the water as well as changes in the flow rate—or quantity—of the water. This provides a still higher degree of automation by instrumentation.

* The Quality-Quantity Chlorinator, a product of Wallace & Tiernan Inc., Belleville, N.J.

An auxiliary instrument of importance to a complete program of chlorination is a chlorine flow recorder. It provides continuous and permanent records of chlorine feeder performance and can provide positive indication of feeder operation at remote points. It also provides a constant check on chlorine consumption. Loss-of-weight recorders on chlorine scales perform a similar function. Records from a chlorine flow recorder, a residual recorder, and the plant flow meter can make up a complete picture of the chlorination program of any plant.

Detector

A chlorine detector † has been developed that will fit in with a safety program for handling chlorine. A constant stream of air sample is directed onto a sensitized tape which darkens in the presence of chlorine. A detector cell scans the tape for discoloration. Capable of sensing minute quantities of chlorine in air, it will actuate audible and visual alarms to alert personnel of the presence of escaped chlorine. It is also valuable in helping protect equipment in unmanned chlorinating stations.

Other Developments

Many other new instruments and improvements of existing ones have appeared at regular intervals. Their introduction was less dramatic than the advances previously cited but their contribution has been no less vital. Equipment to provide remote adjustment of chlorine feeders to make possible the centralization of chlorine feed control is one example. A chlorine feeder at a remote intake, for instance, can be adjusted by an operator at the main plant.

Remote indicators and recorders for residual recording can be installed in a central location even though the sampling cells may be located at various points in a well field or at reservoirs in the distribution system.

Another instrument for dosage control—used more often in sewage plants than water treatment plants—programs control of dosage rate in order automatically to adjust a preselected dosage rate at a preselected time (*13*). Other instruments of utmost importance are the various devices used to convert signals from flow-measuring devices to appropriate signals for controlling chlorine feeders and accessory equipment.

Conclusion

There has been steady progress in the application of instrumentation to chlorination. This has been required by and resulted from: [1] the demand for automatic and remote control, [2] the need to record chlorination rate and residual level, [3] the use of chlorine in water treatment for purposes other than disinfection, [4] the recognition of different types of chlorine residuals, [5] the employment of free residual chlorination and chlorine-ammonia treatment, and [6] the need of controls to effect efficient operation.

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† The Solvay Chlorine Detector is manufactured by Wallace & Tiernan Inc., under patent license from Solvay Process Div., Allied Chemical & Dye Corp., New York, N.Y.

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California Regulations for Red Lights on Utility Vehicles

Seth K. Martin

A paper presented on Oct. 31, 1957, at the California Section Meeting, San Jose, Calif., by Seth K. Martin, Lieutenant, Special Services Section, California Highway Patrol, Sacramento, Calif.

IN a consideration of the laws and regulations in California pertaining to the use of red lights on public utility vehicles and the various exemptions granted these vehicles, the technical nature of the subject necessitates the explanation of the statutes.

Section 592.1 of the California Vehicle Code provides that restrictions in other sections prohibiting the stopping, standing, or parking of vehicles shall not apply to the driver or owner of any service vehicle owned or operated, by, for, or under a contract with a utility, whether privately, municipally, or publicly owned, if the vehicle is used in the construction, operation, removal, or repair of utility property or facilities. If a utility vehicle is stopped, standing, or parked at the site of work involving the construction, operation, removal, or repair of utility property or facilities (on or near a street or highway), it must display certain warning devices.

During daylight hours, warning devices include a warning flag, sign, or barrier on the highway not more than 50 ft in front of the vehicle and not more than 50 ft to the rear; if the maximum speed limit in the area is over 25 mph, the distance may be increased up to 500 ft from the vehicle, as circumstances may warrant.

During hours of darkness or any other time when there is not sufficient light to render clearly discernible any person or vehicle on the highway at a distance of 500 ft, the warning devices must consist of: [1] one or more lights or fusees on the vehicle giving warning to approaching traffic from each direction; or [2] a warning light, flare, fusee, or reflector on the highway not more than 50 ft in front of the vehicle and not more than 50 ft to the rear, with the same provision for zones where the maximum speed limit is over 25 mph.

No other warning devices are necessary at any time if the vehicle is an authorized emergency vehicle within the provisions of the vehicle code and is equipped with a flashing red light or lights visible to approaching traffic from each direction.

Emergency Vehicles

When approved by the commissioner of the California Highway Patrol, emergency repair vehicles of a public utility may be equipped with a siren and a steady burning red light visible to the front for use in responding to emergency calls. In addition to the forward-burning red light required by the vehicle code, such authorized emergency vehicles may also display flashing or other red lights, including revolving red lights to the sides or rear.

Another section of the code provides that any emergency vehicle of a public

utility, used in responding to emergency calls for the repair or maintenance of its services, may be approved by the commissioner of the California Highway Patrol for operation, when equipped with a red light or lights of the steady-burning, flashing, or revolving type for purposes of identification, if the vehicle has no siren. Such vehicles equipped with red lights only are not authorized emergency vehicles and are not entitled to the exemptions granted authorized emergency vehicles by the vehicle code.

Additionally, public utility repair vehicles necessarily parked other than adjacent to the curb in a highway for purposes of repairing public utility services may be equipped with red lights displayed to the front, sides, and rear. These red lights cannot be lighted when headlamps are lighted and must be of the steady-burning nonflashing type. Revolving red lights are not permitted. Public utility repair vehicles equipped with nonflashing red lights used only for the purposes specified are not required to obtain a red light permit from the commissioner of the California Highway Patrol.

Any public utility may have selected vehicles classified as emergency repair vehicles, equipped with a siren and a red light or lights and used in responding to emergency calls, or as emergency service utility vehicles, equipped with red lights only for purposes of identification. The utility may equip such vehicles with flashing or revolving red lights, by obtaining the necessary application forms for a permit from the California Highway Patrol.

Summary

The laws and regulations governing the issuance of permits for vehicles of a utility and their use of red lights may be summarized as follows:

1. Authorized emergency vehicle permits may be issued for emergency repair vehicles used in responding to emergency calls.
2. Red light permits may be issued for emergency vehicles used in responding to emergency calls for the repair or maintenance of its services.
3. Vehicles operating under authorized emergency vehicle or red light permits may display red lights while in motion. Such vehicles may display additional red lights, which may be of the flashing or revolving type.
4. Vehicles for which permits have not been issued may display red lights only when parked, but these lights cannot be of the flashing or revolving type.
5. Vehicles operating under a permit and equipped with a siren must have the sirens approved by the highway patrol. Two classes of sirens have been established: the high-performance siren, for outside mounting or mounting behind a grill or under the hood; and the medium-performance siren, approved for outside mounting only.
6. Vehicles operated under an authorized emergency vehicle or red light permit must be equipped with at least one red warning lamp not less than 5 in. in diameter. The lamp must be mounted above the level of the hood showing to the front and must provide an adequate warning for 500 ft ahead of the vehicle, under normal daylight conditions.

Members of the Association who wish to examine the exact provisions of the law are referred to Sections 592.1, 44(f), 454, 650.7, 44.2, and 640(d) of the California Vehicle Code, as well as Sections 692(d) and 753(a) in Title 13 of the California Administrative Code. Additional information may be obtained from the California Highway Patrol, P.O. Box 898, Sacramento, Calif.

Safety Regulations for Industrial Vehicles in California

Vincent L. White

A paper presented on Oct. 31, 1957, at the California Section Meeting, San Jose, Calif., by Vincent L. White, Supervising Constr. Engr., Div. of Industrial Safety, San Francisco, Calif.

VEHICLES are a leading cause of deaths on, as well as off, the job. Statistics for on-the-job fatalities show that vehicles were involved in 298 fatalities in 1956, more than 35 per cent of the total industrial deaths for that year.

Motor trucks are the cause of more than one-third of these fatalities, followed by automobiles with a little less than one-third. Tractors are also important, having a part in about one-tenth of the fatal injuries.

A great many of the industrial vehicle injuries and deaths happen in the same way that common automobile accidents happen, and the means of prevention are about the same. In this type of accident, the California Division of Industrial Safety relies to a large extent on the state vehicle code (*1*) to provide the necessary regulations, at the same time recognizing the need for cooperation with numerous agencies in the matter of education and training. Vehicle regulations adopted and enforced by the division are not aimed at the common type of highway accident.

Use of Trucks

One regulation that touches the industrial field is a construction safety order (*2*) applying to the transportation of workers in trucks and buses. In brief, it can be said that any truck used primarily or regularly in this service—about once a day or more—must have secure seats, railings, and steps for mounting. In other words, if the truck is to be used regularly in this service it must be altered to make it suitable (Fig. 1).

It is occasionally permissible to use ordinary types of trucks for the transportation of workers, but "occasionally" is intended to mean that the truck is seldom used in such service. Under these circumstances, flat-bed trucks, dump trucks, and pickups may be used, but the man load is limited to those inside the cab plus not more than two men outside of the cab, unless certain hazard-reducing precautions are taken. In general, these precautions call for the men to be seated on the floor of a truck bed that has rails or sides. A pickup truck with the tailgate closed satisfies this requirement, as does a dump truck with the bed locked down and the tailgate closed.

Employees may stand or sit immediately behind the cab of an unrailed flat-bed truck provided that they hold on to suitable grab irons which are rigidly fastened to the truck, but they may not ride on the tops of side rails, running boards, or fenders, or with their legs hanging over the sides. Construction

workers may ride on stable loads, if they are seated in a safe place.

There are also regulations applying primarily to the use of vehicles in tunnels or mines. In general, no internal combustion-engine equipment may be used in underground work without written permission from the division. Few water utilities are likely to become involved in the excavation of a tunnel, but some of the larger water companies have occasionally requested permission to use diesel equipment inside of large water conduits or tunnels that need repairs. Arrangements can be made to allow such operations, provided that certain health standards are maintained through the use of carbon monoxide tests and adequate ventilation. The use of gasoline engines underground is not allowed, unless a special order has been issued in advance.

Special Devices

Other important regulations applying to trucks include a safety order which calls for an automatic warning device on certain trucks whenever they are backing. This regulation applies to trucks with a body capacity of 2½ cu yd or more, that are used to haul dirt, rock, concrete, or other construction material. More and more truck owners are equipping their trucks with these devices, which are required unless the regular horn is sounded just

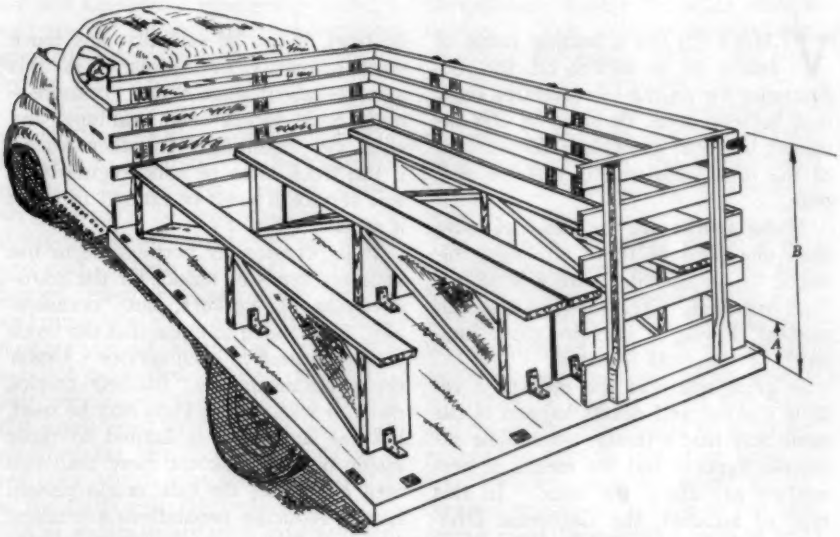

Fig. 1. Benches Installed on Stake Body Truck

When this type of truck is regularly used for transportation of personnel, California specifications call for safety standards such as those indicated above. The bottom board, flush with the truck bed, should be at least 8 in. in height (A)*; sides and end gates, part of which are shown, should be at least 42 in. high* (B).

prior to, or immediately following, the start of backing. Another acceptable substitute for the back-up warning device is a signal man, in clear view of the operator, who directs the backing operation. One common automatic warning device that has been acceptable involves the installation of a bell-shaped hub cap on the rear wheel. Gongs activated by centrifugal force strike this bell whenever the truck is in reverse, thus giving the necessary warning. Other satisfactory devices connect up to some suitable power source such as the speedometer gear at the transmission.

There is also a regulation calling for cab shields on trucks. These shields are attached to the dump body of the truck and extend over and above the cab. This regulation applies to those 2½-yd or larger trucks that are loaded by power equipment, such as drag lines, power shovels, or clam shells of ¾-yd capacity or larger. This means that the requirement is intended to apply only to trucks handling materials like gravel, rock, dirt, or brick. The cab shield, of course, is to be so designed that it offers some real protection to the driver's compartment from falling material of the type being handled.

Repairs and Adjustments

Vehicle regulations applying to the repair of tires call for safety tire racks or cages to be used when inflating truck or equipment tires, if such tires depend on a locking ring or similar device to hold them on the rim. The purpose of the construction safety orders (*2*) is to have such tire racks at all the shops or repair centers. Compliance should eliminate much of the hazard from all but emergency field repairs which, of course, are allowed without such protection. Defective or poorly installed rings sometimes spring forcefully from the rim during inflation.

Another safety order requires that haulage vehicle brakes, steering gear, and similar control devices be inspected or tested at least once each shift, preferably before the vehicles are taken from the storage areas. The test, of course, should be conducted by the vehicle operator, unless other arrangements are made by the employer. Here again there is need for interest and determination on the part of management that these inspection rules be followed.

For some kinds of repairs and adjustments to trucks, men must go into the danger area under raised dump truck bodies. These raised truck beds have proved to be a hazard to those who expose themselves underneath, which is the reason for a safety order requiring dump truck bodies, bulldozer blades, or carryall closing gates to be blocked in the raised position if a man is to work underneath. Some truck owners have taken the commendable precaution of installing a hinged body block, permanently attached to the truck frame and ready for service at any time, wherever the truck happens to be. Others have had the foresight to keep a supply of blocks specially suited for this service at shops and repair areas. Some, who have had no foresight at all in this matter, can only say, "I can't understand why our man took that risk."

Cranes

Cranes are sometimes considered as vehicles, because they are ordinarily quite mobile. One important electrical safety order (*3*), applying to cranes and similar equipment, prohibits their operation in a position where it is pos-

sible to swing or boom to any point that is within 6 ft of a high-voltage line. It is also a violation of the California Penal Code to operate a crane within 6 ft of a high-voltage line. In addition, these regulations require a sign to be posted in clear view of the operator, warning him and others against this violation. There are about 30 California workers killed each year by electrical shock, and one major problem is the contacts with high-voltage lines.

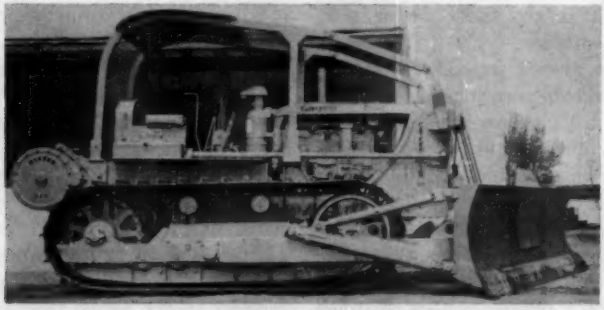

Fig. 2. Tractor Equipped With Protective Canopy

This is a requirement for units engaged in work that would subject them to the possibilities of falling limbs, trees, or rocks.

Another regulation for boom-type cranes and similar equipment requires a boom stop, which will prevent the boom from falling over backward onto the crane cab. A boom without such a device can be hoisted too far by an inattentive operator, with disastrous results for himself and the crane. It sometimes happens that a heavy load is suddenly dropped due to rope breakage or some other mishap. This instantaneous release often provides enough impulse to snap the boom backward onto the cab, unless there is a functioning boom stop. The best boom stops make use of spring or hydraulic buffers. Buffers help to absorb the energy of a snapping boom without stopping it too suddenly. Automatic clutch release and brake-setting devices are also of value. They protect against disastrous operator errors, by disengaging the power and setting the brake whenever the boom is raised to a position dangerously close to the vertical. Ordinary cranes should not have an automatic clutch release without an automatic brake-setting device which will hold the boom in its raised position.

Other Machinery

Tractors that are subjected to the hazards of falling trees, limbs, and rocks must be equipped with canopy covers (Fig. 2). This means that all such units used in tree-clearing operations must be so equipped, as well as many tractors used on road work where the cuts are so steep that rocks may fall from above.

Trenching machines are certainly of interest to this group. There are many safety orders applying to trenches, but regulations applying to trenching machines are mainly those requiring the guarding of gears, sprockets, and chains. These orders apply to all ma-

chinery, including vehicles of any kind. In general, they require that all accessible gears and sprockets be enclosed by a guard. Chains of sprocket and chain drives must be guarded whenever located within 7 ft of the floor or other working level. On trenching machines the main sprockets and chains near the operator's platform can be guarded with a large screen guard of the shield type. In addition, it is necessary to guard the sprockets of the conveyor, but it is usually impossible to guard the conveyor chain that turns these sprockets, which are located at each end. Any exposed shafting, shaft ends, couplings, belts, or pulleys that are within 7 ft of the floor or working level must be guarded from contact. Vehicles are not exempted from these or other required guards, which have been proved necessary by serious accidents.

Conclusion

In review, it might be said that these regulations on vehicles are industrial in nature. Their purpose is to cover those areas of vehicle hazards that are not included in broader laws aimed at the general problem of highway safety. There are, of course, many injuries related to vehicles that do not call for regulations of a type that could be written as law. Many men, for example, strain or bruise themselves by sudden movements in getting into or out of vehicles that are not in motion. The Division of Industrial Safety is continuing to watch the statistics on vehicle accidents, however, to make sure that it is not overlooking important sources that could be eliminated, in part, by reasonable regulations on subjects not covered in the vehicle code or in similar laws.

Accidents of a nature that do not lend themselves to control by regulations are, of course, being prevented to some degree by educational and promotional activities. Because of his longtime membership and association, the author is especially familiar with the American Society of Safety Engineers, a professional organization which originates many activities of this type.

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Aerial Mapping Service of the US Geological Survey

Daniel Kennedy

A paper presented on Oct. 15, 1957, at the Southwest Section Meeting, Oklahoma City, Okla., by Daniel Kennedy, Central Region Engr., Topographic Div., USGS, Rolla, Mo.

THE term "aerial mapping," at least until the very recent past, has carried the implication that aerial photography was the sole technique used in the compilation of maps by aerial means. Experiments are now being conducted, however, that could result in the production of maps by aerial methods other than aerial photography. Data for compilation would be obtained by a type of electronic measuring device similar to the radar altimeter and would be stored on a magnetic tape used later in making the map. Although such projects are not the subject of this discussion, they are cited in order to avoid creating the impression that aerial mapping is limited to photography as a means.

Modern topographic mapping has used aerial photography for many years; in fact, photogrammetry—the science or art of obtaining reliable measurements by means of photography—is over a 100 years old. The reason this is surprising to most people is explained by the fact that widespread use of photogrammetry was started only after World War I, when the airplane was developed to the point where its flight could be controlled to minimize tilt, tip, and other sources of error. Subsequently, equipment was developed which was capable of accurately measuring a photographic image and which made the photographs usable in map making. In the thirties, this equipment caused a major change in map compilation and photogrammetry is now used in virtually all topographic mapping projects. The accuracy obtainable in a photogrammetric map compilation is a function of the characteristics of the aerial photography. Thus, preparing and enforcing the proper specifications for the photography is a key step in obtaining the desired accuracy. Roughly, the flight altitude is fixed by the contour interval desired and is planned to be about 600–1,000 times the contour interval. In mapping terms, this relationship is referred to as the *C*-factor.

A variety of stereoscopic plotting instruments are available today. Instruments designed for greater versatility and higher precision are, as a rule, more complex—with the cost increasing with the complexity. Large mapping organizations like the USGS are generally equipped with a number of different types of instruments. The choice of equipment to be used on a particular project depends on which instrument has the characteristics capable of fulfilling economically the requirements of scale, contour interval, and accuracy.

Organization of USGS

The topographic division of the USGS maintains its headquarters in Washington, D.C., and is headed by the chief topographic engineer. Two staff branches do the work of research, technical control, planning, and coordination, with the normal complement of administrative personnel for fiscal, personnel, and procurement purposes. The actual map making is done by the four regional offices at Sacramento; Denver; Rolla, Mo.; and Arlington, Va. The area covered by the regions varies both in size and number of states; the central region includes thirteen states.

Instruments

Many new types of both field and office equipment for map making have been developed during the last few years. The airplane and the aerial camera have brought a new era to mapping. Stereophotogrammetric instruments (Fig. 1) allow image measurements to be made with the utmost precision. At the present time, there are many such instruments in this country, both American and foreign made.* An important characteristic of some of the more versatile instruments is that they can be used for the extension of control. This feature can reduce the required ground control—a very expensive part of aerial mapping. Electronic techniques have been adapted to geodetic triangulation, the measurement of elevations, and the solution of complex mathematical problems. A new level, using a pendulum principle, is giving excellent results. Color-separation drafting for lithographic reproduction of maps is also undergoing a change. The method of scribing—using engraving tools to scribe through a processed coating on a plastic base—can be done by draftsmen and gives a map equal in appearance to one done by the copper engraver.

Sequence of Operations

Mapping operations in the central region of USGS employ about 575 persons, of whom about 275 are engaged in field operations. Rotation of duties between field surveys and photogrammetry is required for full professional development. The sequence of operations begins with the procurement of aerial photography and is then followed—sometimes preceded—by basic horizontal and vertical control. Picture points are selected by the photogrammetric section and elevations are obtained for these in the field (Fig. 2). This is followed by stereocompilation. Map manuscripts in the form of advance prints become available at this stage. Field completion occurs later, when the manuscript goes to the field for the checking of features, names, types of drainage, road classification, and the usual boundary problems. The map then enters the preparatory phases for reproduction by printing. The length of the mapping

* Among the most common are the Multiplex, Bausch & Lomb Optical Co., Rochester, N.Y.; the Kelsh plotter, Kelsh Instrument Co., Inc., Baltimore, Md.; the ER-55 plotter, developed by USGS; the Stereoplanigraph, Carl Zeiss, Inc., New York City; the Autograph, Wild Heerbrugg instruments, Inc., Port Washington, N.Y.; the K.E.K. plotter, Philip B. Kail Associates, Denver, Colo.; the Stereocomparagraph, Fairchild Camera & Instrument Corp., Syosset, L.I.; the Contour Finder, Abrahams Instrument Corp., Lansing, Mich.; and the Twinplex, developed by USGS. At present, the central region office of the USGS uses the Multiplex, the ER-55 plotter, the Twinplex, Kelsh, and Autograph equipment.

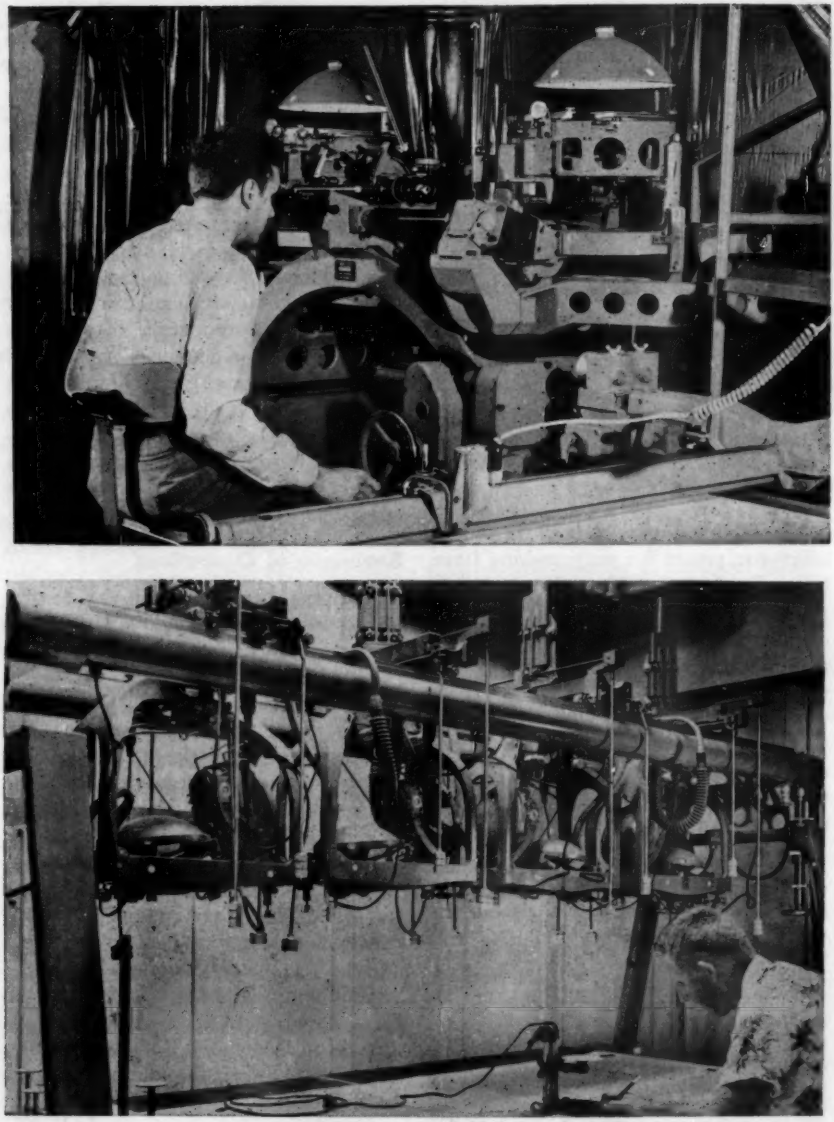


Fig. 1. Two Stereoscopic Plotting Instruments in Use

Instrument at top is a mechanical projection type of medium complexity which utilizes vertical photography and produces mapping of very high accuracy; lower view is of instrument which utilizes low-oblique, wide-angle photography.

cycle is dependent upon some factors which are uncontrollable, such as aerial photography, which, in turn, depends upon the seasons of the year and the foliage situation. Maps have been completed on occasion in 15 months where the need was especially critical; the typical time cycle is somewhat longer.

Oklahoma City Project

The present USGS project in Oklahoma City began with a request by the Washington, D.C., office—which had received a letter of inquiry from Senator Kerr regarding a cooperative mapping agreement with Oklahoma City—to discuss with city authorities the standard agreement, the type of mapping, its cost, and the time required for completion. All phases of the subject were explored on Dec. 28, 1955, and the project was arranged in the usual manner as part of the USGS standard quadrangle mapping program. The project was expedited because the cooperating agency—Oklahoma City—urgently needed the maps for reservoir development and was in a position to provide half the cost immediately.

On Jan. 9, 1956, the agreement was signed and normal operations started. Unfortunately, the winter months of January and February did not provide the best photographic weather but the contractor, with assistance provided by the Rolla, Mo., office of the USGS, obtained the photography and delivered it on Mar. 3, 1956. In the meantime, basic control parties were operating in the areas of highest priorities and, when the photography became available, supplemental control was started.

There were twelve 7.5-min quadrangles in the reservoir project. These were requested in three priorities—those four in the first priority required within the first 6 months, followed by two more quadrangles within 9 months, and the remainder within 1 year. These were to be in the form of advance sheets with all regular map information, including land office and field completion data. The normal map-finishing phases necessary for reproduction were not included in this time plan, but were to be done later as part of the cooperative agreement.

Work on the first priority was completed by Apr. 23, 1956, that in the second portion on May 9; and the remainder by Nov. 16, 1956. When it is considered that inclement weather prevented getting the photography until Mar. 3, it is clear that field and photogrammetric groups did an outstanding job.

Fig. 2. Plane Table and Alidade

Devices are used in field aspects of aerial surveys.

At this point, it was decided to complete the mapping of the fifteen quadrangles necessary for pipeline and

canal locations and the agreement for these additional areas was included in a supplemental statement added to the original document. This was agreed upon on Jan. 9, 1957, with schedules established as follows: three quadrangles to be completed through the advance-print stage within 6 months, six quadrangles within 9 months, and the remaining six within the year.

The photography for this extension was delivered by the contractor on Mar. 25, 1957, and the first quadrangle was completed Aug. 18, 1957, with four more completed Sep. 12 of the same year. Because time schedules on this extension were based upon receipt of photography, the project is well ahead of forecasts and work will be completed well within the required time.

Unfortunately, maps, like other things, become old and obsolete and, although efforts are made to carry on an adequate map maintenance program on the mapped areas, new requirements—such as more detail and greater accuracy—often make it necessary to remap certain areas. The old maps of the reservoir area just discussed were made in 1900 and bear witness to these changes in mapping requirements.

Conclusion

The description of the Oklahoma City mapping has been brief and relatively undetailed. The map information office of the USGS in Washington is ready to furnish information and maps upon request and will arrange to process requests for photos and advanced prints when they are available. For other information regarding programs, future mapping projects, or activities of the other divisions of the Survey, inquiries of the director or the chief topographic engineer of the USGS at Washington will receive a prompt reply.

Leak Abatement Techniques at St. Louis

Carl F. Buettner

A paper presented on Sep. 30, 1957, at the Missouri Section Meeting, St. Louis, Mo., by Carl F. Buettner, Civ. Engr., Water Div., Dept. of Public Utilities, St. Louis, Mo.

THE problem of water waste and leak abatement is common to water utility men the world over, and has been since the beginning of potable-water delivery. No one has yet come up with an ironclad means of preventing waste, but the sharing of techniques and experiences will benefit each and every utility will be where it really counts—in the cash register. St. Louis holds no unique solution for curbing water waste, but the methods to be outlined here will reflect real savings and these methods, reduced or expanded, could be put into effect in any size of city, town, or village.

The distribution system in St. Louis is made up of approximately 1,300 mi of mains, ranging in size from 4-in. to 62-in. diameter; 21,800 gate valves; 15,500 fire hydrants; and 180,000 service taps. Only 11 per cent of all service lines are metered, which tends to make the average consumer less concerned about leaks than 100 per cent metering would. To illustrate further why St. Louis needs good leak abatement techniques, the 89 per cent flat-rate accounts pay an average water bill of $16 per year, a little more than 4 cents per day for an unlimited supply, night and day, 7 days a week.

From past experiences and tests, it is estimated that approximately 2.15 mgd are wasted through leaking fixtures and 3.48 mgd wasted by leaking service lines. Underground losses on the distribution system itself, including mains, fire hydrants, and valves, account for about 4.46 mgd. The total of 10.09 mgd of wasted water flowing down the sewers every day is enough to concern any water utility man.

St. Louis utility personnel cannot fix broken service lines, because they are owned and must be maintained by the property owners. It is not possible to have a man travel with every street-flushing crew, fireman, and contractor to make sure the fire hydrants they use are shut down properly. It cannot be foretold when a 36-in. main might break, and present ordinances do not permit the metering of every service. Utility personnel are resigned to the fact that they cannot prevent the causes of leaks, but they are determined that leaks will not continue for any extended period of time.

Since 1930, the distribution engineers, together with Pitometer engineers, have made periodic surveys and have divided the city into seven districts. Each district has in turn been divided into eight to twenty sections, depending on the type of development, such as residential, small mercantile, industrial, or factory. These districts serve as a basis for the leak abatement program in the city.

Searching for Leaks

A crew of six field inspectors, under the supervision of a supervisor, meets

every morning at a designated point in the assigned section, with specific instructions to sound every hose bib for leaks and to go inside and check for leaking pipes in the basement, faulty washers in fixtures, or any other indications of leakage. These men need only the basic tools for detecting leaks, an aquaphone and a flashlight. In the event a toilet or faucet is found to be leaking, the inspector fills in a printed form, stating the nature of the leak and noting that it must be corrected within 10 days, or the service will be shut or metered. If, after sounding the hose bib, he suspects that the service line is leaking, he notes that fact on his daily work sheet, to be rechecked by the supervisor, who, having a greater assortment of tools, can shut the tee head or valve and verify the inspector's suspicion. In walking from house to house, these inspectors also note any water coming out of fire hydrants, valve boxes, or water surfacing in the street. Such signs are reported each evening to the supervisor, who takes appropriate action. Another phase of work carried on by these inspectors consists of notifying the property owners if the stop box is found to be high, low, covered, broken, or otherwise defective, thus reducing the chance of injury. Valve and meter boxes, which are the property of the water division, also are reported if found high, low, or in need of repairs.

The second phase of the leak abatement program is handled by five field inspectors under direct supervision of a distribution engineer. These men are assigned a radio-equipped car with the various tools and valve keys necessary for making practically any type of shutdown. Two of these inspectors are in south St. Louis, two are in north St. Louis, and the fifth man rechecks previous leaks turned in by all inspectors combined, to determine if repairs have been made within the specified time.

Investigating Complaints

North St. Louis, which consists of approximately 31 sq mi and has practically every type of residential and business establishment possible, may be used as an example. The inspectors are dispatched by radio from a central office, where complaints are received from citizens. One is equipped with a pipe locator and the other with a water leak detector mounted in the car. Both men are very capable and are qualified to handle the equipment. As a complaint is received, it is given immediately to the inspector who is closest to the location of the complainant. He in turn investigates, notifies the property owner with a written notice of the trouble, and fills out a short simple form, which is recorded and filed with the dispatcher.

If a property owner or tenant is not home, the dispatcher writes out a form notice, stating the nature of the investigation, and mails it to the responsible party. The recheck inspector then follows up after 10 days, to see if the trouble has been eliminated. If not, a 5-day extension notice is given, and if, after this extended time, the leak is still not fixed, the supply is shut off at the tee head, and the stop box is slugged. A few of the citizens, trying to avoid this action, cement or otherwise block up the stop box to prevent its being shut. This just adds insult to injury, because a water department crew is then dispatched to dig and shut the tap at the main, with the owner being billed for this work.

If the day happens to be fairly slow as far as complaints are concerned, the inspector with the pipe locator assists plumbers, contractors, and water division crews, in tracing out service lines

or mains and witnessing the destruction of taps on abandoned services that are dug and exposed by plumbers.

Other Features

The other inspector with the leak detector is in demand all the time. His ability to pinpoint leaks on mains, service lines, or joints, before a single shovel of dirt is turned, has saved the department countless thousands of dollars, which would otherwise have been spent in digging dry holes. With labor costs mounting and officials complaining about blocking traffic, it is readily apparent that this man's ability to use the leak detector properly and efficiently is indispensable. In the event this inspector is not working with a crew, he is available at any time to drive to within a few feet of any fire hydrant or valve, attach the leak detector receiving cord to the operating nut, and in a matter of seconds determine if any leakage exists, either by audio or visual indications.

Another important item is the form notices that the inspectors fill out, when notifying the property owner of any type of leak on his premises. A copy of this information is supplied to a water division clerk, who records it on a 5 × 7-in. file card, which is made a permanent record. Each address in the city has its own card, listing not only trouble calls made, but also the owner's name and address, location and size of the tap, its date of installation, the plumber's name, and whether or not the supply is metered. This record has proved to be invaluable.

Conclusions

A considerable financial saving is effected in St. Louis every day that its eleven inspectors are in their assigned positions. It has already been stated that the estimated water waste amounts to approximately 10.9 mgd. If these leaks were permitted to go unabated, waste would total nearly 4 bil gal per year. It costs approximately $148,000 to produce this amount of water. The combined salaries of the inspectors amount to approximately $44,000 per year, so that it can readily be seen that $104,000 is saved every year in pumping and production costs alone.

St. Louis, unlike many communities, is blessed with an almost unlimited supply of water. Where supplies are limited, water waste abatement is of prime importance. If utilities cannot afford to contract for an extensive engineering survey and 100 per cent metering is for some reason not possible, communities should secure the services of a capable man, give him the necessary tools, and instruct him thoroughly in the policies of the department. Before long the leak inspector will develop to where he is really earning money—money that can be put to a better use than pouring water down the drain.

Discussion

Thomas J. Skinker

Recently Retired Water Comr., St. Louis, Mo.

To appreciate the reason for the techniques described in the foregoing paper, it should be understood that water waste control in St. Louis is limited to unmetered services, leakage between the water main and the meter on metered services, fire hydrants, and water mains. There is a very large

amount of waste that has not been mentioned by the author, undoubtedly because the water division, over the years, has been unable to do anything to stop it.

No charge is made for water furnished to city departments. In the hospitals and other city-owned buildings that have refrigeration and water-cooled air-conditioning installations, no attempt is made to conserve water, and as these services are not metered, the amount of this waste is not known.

Beginning in 1928, the water division made card records of each of the premises inspected, and it now has approximately 128,000 of these cards, which show each leakage that has been found on the property.

The Pitometer Associates, Inc., after completing a water waste survey of the city, stated that by metering all premises where leaks were frequently found, most of this kind of waste would be stopped. There was so much political objection to this, however, that they were never metered. Inspections made during freezing weather revealed more than 500 premises where faucets were open and water was allowed to run day and night. Here again, political objections prevented metering.

The waste by the park division at their ponds and lakes is uncontrolled, and little attempt is made to conserve water.

In spite of all this waste, water rates in St. Louis have not been increased since 1918. The highest rate charged by meter is 15 cents for 750 gal.

Although there has been almost no increase in population, the per capita consumption has increased from 149 gpd in 1931 to 211 gpd in 1956. In addition to uncontrolled waste, this increase is undoubtedly due largely to air conditioning, automatic washing machines, and garbage disposal units. Most of these installations are on unmetered services, and there is no flat-rate charge for any of them.

The St. Louis procedure described locates, records, and temporarily stops the waste on these premises, but there is only one way to control this waste, and that is to meter the premises and make the consumer pay for all water used.

Economics of Meter Maintenance Programs

Parker M. Robinson Jr.

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by Parker M. Robinson Jr., Engr. of Operations, California Water Service Co., San Jose, Calif.

ON many occasions the water meters on consumers' services have been compared to cash registers. This is an apt comparison inasmuch as the revenue that the water system collects is based upon the consumption registered by the meters. Ideally then, every water meter should register 100 per cent of the water passing through it. Practically, this is impossible, so a compromise has to be made. At the time a meter is put in service a registration accuracy of $\pm 1\frac{1}{2}$ per cent is considered reasonable. After the meter is placed in service, wear takes its toll on its accuracy, which generally means a loss in revenue. It would seem then that, from time to time, meters should be overhauled to keep this lost revenue to a minimum, but the overhauling of meters costs money. The problem then becomes one of finding the time at which lost revenue and overhaul expenses combine to give the lowest cost.

In order to put a dollar value on the revenue lost through inaccuracy, it is necessary to know how much water a consumer receives that is not registered by the meter. A shop test on a meter will not give this answer. Anyone familiar with water meters knows that the accuracy of registration varies with flow rates. A shop test will show what the accuracy is at any particular flow rate, but the real difficulty is in determining what portion of the consumer's total consumption is taken at each of the many different flow rates. Trying to solve the problem in this manner leads either to a dead end or the making of unsupportable assumptions regarding the distribution of flow rates.

Fortunately, there is a way around this problem. One solution is to install a meter, specially selected for accuracy, in series with the regular service meter. In this way it is possible to integrate the consumption for an infinite number of flow rates. The difference between the two meter readings, then, is consumption lost through inaccuracy of the service meter. This can readily be converted to dollars.

Meter-Testing Procedure

In actual practice, a testing program for $\frac{5}{8}$-in. meters might be set up as follows:

First, the services on which tandem meters are to be set should be selected, with the following points in mind:

1. Select services with meters that have been in service for various numbers of years. A wide enough selection of years in service should be used so that the final data will include the point at which the cost of a repair program is at a minimum.

2. Select services with past consumption records that appear to be

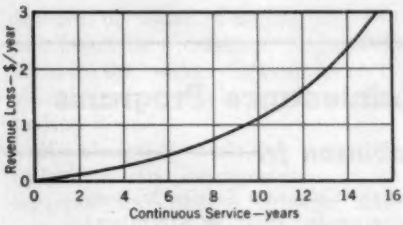


Fig. 1. Average Annual Loss in Revenue per Meter

When a curve such as this has been plotted, figures can be totaled for computing the cumulative loss (Fig. 2).

average or normal. It might be well to consider sampling more than one consumption group, such as one group that normally shows small consumption, another group that shows average consumption, and a third group that shows high consumption.

3. Statistically speaking, the larger the number of services tested, the more nearly representative the results will be. In any one category of meter age and consumption record there should be enough meters tested to insure getting a representative average as well as providing for such contingencies as a stuck meter, or a turn-off during the test period. Three meters would probably be an absolute minimum for each category.

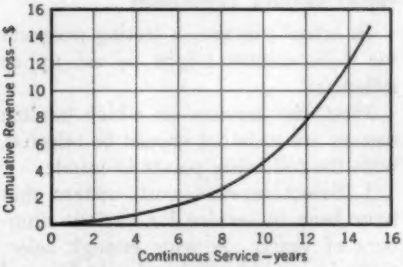


Fig. 2. Cumulative Loss in Revenue per Meter

By totaling the revenue loss for each year (from Fig. 1), the cumulative revenue loss for any given period of service is obtained.

The next step is to select the test meters to be installed in series with the service meters. In general, these are best chosen from a stock of new meters and should meet the following stringent accuracy requirements.

Rate of flow *gpm*	Registration *per cent*
¼	97–100.5
¾	100–101.0
2	100–102.0
5	100–101.0
10	99–100.0

It has been found that, although all new meters will meet normal accuracy standards, only about one in four will meet these higher standards. It is particularly important that the registration at ¼ gpm be as accurate as possible.

The specially chosen meters should be installed in series with the service meters to be tested. By arranging the two meters in a U shape, it is possible to get both meters within a single No. 36 meter box. This arrangement has the additional advantage that it is not necessary to cut a piece out of the service, thus making it very simple to restore the service to its original condition at the end of the test period.

A special meter-reading book should be set up and the meters read at regular billing intervals for a period of 1 year. The special book is desirable so there will be no confusion with reading of meters for billing purposes. For purposes of the test all dials on the meter should be read, rather than just the first three, which is common practice for billing readings. For this portion of the test, a period of 1 year is suggested so that a full cycle of seasonal load variations is covered.

At the end of the test year, both the service and test meters should be removed and tested in a shop at the same five test rates used for selecting the test meters. The test on the test meter provides information on the effect of 1 year of operation on its accuracy of registration. From this it can be determined whether any adjustments are needed in the registration figures because of slight inaccuracy in the test meter. The test on the service meter provides the basic information for studies in correlating accuracy and total registration.

Analysis of Costs

The above steps provide all the field data with which to make the analysis, which might proceed as follows:

By simple subtraction, determine the consumption shown by each test and service meter for each billing period of the test. Assuming that billing is normally at 1-month intervals, figure the billing as it would have been for the consumption registered on each meter. The difference between the billing for the test and service meters is then the amount of money lost through inaccuracy of the service meter. It is important that the conversion from consumption to dollars be made in normal billing intervals in order that features of the rate schedule, such as minimums, service charges, and rate blocks, will be taken into consideration in a normal way without distortions.

Based on the assumption that the services selected for testing represent a fair cross section of all consumers with $\frac{5}{8}$-in. meters, the revenue losses for all meters in any one age group can be averaged. In this way an average loss in revenue per meter per year is obtained. In a similar manner, the average annual loss in revenue per meter for each age group tested can be figured.

The revenue loss figure that is really wanted is the total loss between meter overhauls. Unless the test includes meters in all age groups it would be well at this point to plot a curve showing years of service on the hori-

TABLE 1

Cost of Routine Program at Various Time Intervals

Years Between Overhauls	Cost—$			Cost per Meter† $/year
	Overhaul	Cumulative Loss in Revenue*	Total	
1	10	0.06	10.06	10.06
2	10	0.18	10.18	5.09
3	10	0.37	10.37	3.46
4	10	0.63	10.63	2.66
5	10	0.98	10.98	2.14
6	10	1.43	11.43	1.90
7	10	2.00	12.00	1.71
8	10	2.72	12.72	1.59
9	10	3.62	13.62	1.51
10	10	4.72	14.72	1.47
11	10	6.06	16.06	1.46
12	10	7.67	17.67	1.47
13	10	9.63	19.63	1.51
14	10	11.97	21.97	1.57
15	10	14.78	24.78	1.65

* Figure 2.
† Figure 3.

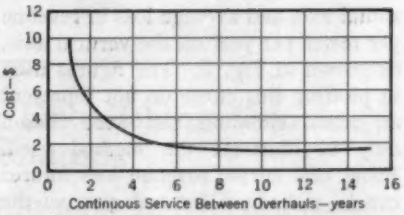


Fig. 3. Cost of Routine Overhaul Program per Meter

Depending upon the number of years between overhauls, the annual cost per meter is as shown (Table 1).

zontal axis and average loss in revenue per meter per year on the vertical axis, as shown in Fig. 1. The figures used in plotting this curve do not represent an actual situation, but were chosen only to illustrate the method used. From this curve, revenue loss figures can be picked off for each year of the period covered. The total loss in revenue per meter for any specific number of years in service, then, is the total of all the annual losses up to that time. For example, the cumulative loss after 3 years in service is the total of the losses for the first, second, and third years. Figure 2 is the cumulative-loss curve based on Fig. 1.

The cost of overhauling the meter should include not only shop labor and parts, but such items as pulling, reinstalling, and transportation. Using a figure of $10 per meter for illustrative purposes, dividing that figure by the number of years in service gives the annual cost of the overhaul. Naturally, the larger the number of years the cost is spread over, the smaller the cost per year.

The final step is to determine when the average cost per year of the overhaul added to the average cost per year of the accumulated revenue loss results in a minimum dollar figure. This then would be the most economical time to overhaul meters on a routine program. Table 1 shows how the cost for the various years is obtained. Figure 3 is a plotting of the resultant figures.

From Table 1 it is apparent that, for the hypothetical figures used, the most economical time to overhaul meters is after they have been in service for 11 years. As Fig. 3 illustrates, however, there is quite a broad span of years when there is little difference in overall cost. This flattening out of the curve near the minimum-cost point is characteristic. From the minimum cost point at 11 years it is possible to increase the period by about 3½ years or decrease it by about 3 years without increasing the cost by more than 10 per cent. This means that other variables not yet considered might be the deciding factor in selecting the time interval for a routine repair program. Without going into detail, such items as the cost of new shop facilities or the expansion of existing inadequate ones, the cost of additional trucks necessary for pulling and reinstalling meters in a newly implemented program, and the money tied up in meter repair parts stock should all be given consideration.

Conclusion

The purpose of this article has been to show the way to arrive at an economically feasible, routine meter repair program. At the same time, it has been demonstrated that because of the many variables that enter into the decision, a separate solution should be worked out for each water system. A list of these variables might include such items as water quality, brand of meters, and workmanship of repairs, to mention a few. It can be seen, too, that as time goes along and changes occur in water rates and overhaul costs, it would be wise to reappraise the program. Fortunately, this is a fairly simple matter as the original field data can be reused.

Toxicologic Methods for Establishing Drinking Water Standards

Herbert E. Stokinger and Richard L. Woodward

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by Herbert E. Stokinger, Chief Toxicologist, Occupational Health Program, USPHS, Cincinnati, Ohio, and Richard L. Woodward, Chief of Water Supply, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

THE problem of evaluating the toxicity and consequent health hazards of industrial water wastes is causing increasing concern to those involved with the control of water quality. The fantastic increase—not only in number and type, but also in volume—of structurally complex chemicals that are difficult to manage after dilution by water scarcely needs emphasis. New materials are constantly being developed for use in water supply and questions of their possible toxicity must be investigated. New pesticides also being developed are often so resistant to biological attack that they persist for months in water.

Although there is no direct evidence that chemical water pollutants have produced or are now producing widespread effects on health or an appreciable reduction in longevity, it is not difficult to envision such a possibility. Present drinking water standards specify regulation of less than a score of some of the more toxic inorganic elements (Table 1) and few are concerned with the organic substances which form a substantial part of industry's waste output.

From the purely toxicologic viewpoint, solution of the problem is far from hopeless; from the epidemiologic and engineering standpoints it is considerably more difficult. Toxicologic data from a variety of sources are available on large numbers of industrial chemicals—often in considerable detail. Fortunately, also, most of the information is derived from feeding experiments, which employ the route of entry which is of primary concern in the evaluation of the health hazards of water wastes. Although a major difficulty will arise in applying these data to human populations generally, the difficulty is not insuperable.

Sources of Information

Currently there are four practical sources of information on the degree of toxicity and hazard for man or animals of a large number of industrial chemicals:

1. The threshold limit values (*1*) for industrial substances in air which have been developed by a committee of the American Conference of Governmental Industrial Hygienists (The list presently comprises approximately 250 substances that can be adapted to the development of water standards.)

2. The tolerances of pesticide residues (*2*) on raw agricultural commodi-

ties established by the Food and Drug Administration (These, based on detailed toxicologic data that are suitable for adaptation to the development of water standards, comprise a group of approximately 90 substances of industrial importance in addition to those appearing in the above threshold limit list.)

3. The toxicologic classification of all substances, both inorganic and organic, according to type of compound (Such classifications may be employed to advantage as a first approximation for the development of limiting concentrations of substances in water. Approximate or tentative standards may be developed for practically all known compounds by assigning reasonable limiting concentrations derived from their appropriate toxicity and hazard categories which, in turn, have been based on toxicologic data on either the specific agent or on closely related substances.)

4. Toxicity data from nutritional studies (Although a rather limited source, it often provides definitive information not obtainable elsewhere. This information may be adapted for the development of water standards.)

Adaptation of Limits for Water

The threshold limit values for industrial substances in air may readily be adapted for water by using reasonable assumptions. These threshold limit values represent a maximal average concentration of a substance in workroom air that provides no hazard to health or well-being of the worker during his working lifetime. Tested under practical working conditions over a period of years, these values have considerable validity. Most have safety factors incorporated which are often of appreciable magnitude. Some of these arise because the values are based on considerations other than health—such as freedom from irritation; others, because of engineering adaptability, may provide large factors of safety to health. The basis for the selection of each value has been documented (*3*) and is otherwise well known (*4*).

TABLE 1

*Typical Drinking Water Standards**

Substance	USPHS† (1946)	Colo.	N.D.‡	Ohio§
Inorganic				
Arsenic	0.05	0.05	—	—
Barium	Not to be added	—	—	—
Cadmium	—	—	0.4	—
Chloride	250.0 R	—	—	250.0
Chromium (Cr^{6+})	0.05	0.05	2.0	2.0
Copper	3.0 R	3.0	0.4	0.4
Cyanide	—	0.5	0.15	0.15
Fluoride	1.5	—	—	—
Iron	0.3 C, R	—	—	5.0
Lead	0.1	0.1	0.35	0.35
Magnesium	125.0 R	—	—	—
Manganese	0.3 C, R	—	—	5.0
Nickel	—	—	0.5	—
Nitrate	—	—	10.0	10.0
Selenium‖	0.05	0.05	—	—
Sulfate	250.0 R	—	—	—
Zinc	15.0 R	—	1.0	15.0
Organic				
Heavy metal glucosides	Not to be added	—	—	—
Oils	—	15.0	—	None
Phenol‖	0.001 R	0.02	—	0.03

* All values expressed in parts per million.
† Key: R—recommended; C—combined values of iron and manganese.
‡ Tentative values.
§ For Miami River and tributaries.
‖ Compounds.

To illustrate how the threshold limit values of a substance in air may be used to arrive at approximate limiting concentrations in water, barium may be used as an example. There is presently no drinking water standard for barium. The threshold limit for barium and its compounds in air is 0.5 mg/cu m. This value is based on the assumption that a worker, during

an 8-hr day, inhales 10 cu m of air. A factor expressing the amount of the barium absorbed into the blood stream from that inhaled must also be considered. This is taken to be 0.75. Accordingly, the amount of barium that is daily taken into the blood stream and presumed to be noninjurious and which, hence, may be taken in water each day is: $10 \times 0.5 \times 0.75 = 3.75$ mg. To calculate the amount of barium in parts per million of water, one must assume that the maximal daily intake of water is 2 liters and one must include also a reasonable factor for absorption via the gastrointestinal tract. A value of approximately 90 per cent for the latter would seem reasonable. Applying this gives an oral intake limit of 4.17 mg barium per day in 2 liters of water—or approximately 2 ppm barium. This derived value of 2 ppm represents an approximate limiting concentration for a healthy adult population; it is only a first approximation in development of a tentative drinking water standard. Several adjustments in this value—discussed later—may be necessary. Other factors, such as taste, odor, and color, may outweigh health considerations because acceptable limits for these may be below the estimated health limit.

Tests of the reasonableness of the value derived may be made wherever possible by resorting to other sources of information. For example, it is known that the average lethal dose of barium for an adult is 550–600 mg (*5*) and 30 mg of soluble barium chloride have been administered 3 or 4 times daily under medical supervision (*6*). A maximum, therefore, of 4 mg barium per day in drinking water would seem to provide, on a single dose basis, a fairly large factor of safety—not only for healthy adults, but for the population at large.

But what is known of the accumulation of barium in the body? Could barium possibly accumulate by daily intake to a level that would prove harmful eventually? Evidence from carrier-free radioisotope studies indicates that barium may be sequestered for considerable periods in bone. Further evidence for the reasonableness of the derived barium value derives from the well known fact that, on a single-dose basis, a glass of 5 per cent "barium-milk" used as an opaque contrast medium for X-ray purposes can be repeatedly taken at infrequent intervals by mouth without harm. It may be calculated from the solubility product of barium sulfate under these conditions that 0.75 mg barium is in solution and available for absorption into the bloodstream. This value is of the same order of magnitude as the calculated value for daily intake. These additional pieces of information make reasonable the first approximation of 2 ppm for barium arrived at by using the threshold limit for barium in air.

Further reduction in this particular value, however, might be indicated to provide additional safety for heterogeneous populations—particularly in view of the known lethality of barium. In this connection, for example, it cannot be automatically assumed that the low solubility product of barium sulfate produced from the natural sulfate content of streams will automatically regulate the amount of barium in a water supply to the calculated amount of approximately 1 ppm. The presence of certain salts such as those of iron, aluminum, and magnesium, solubilizes barium sulfate, making it more available for bodily absorption. More-

over, the possible presence of chelating agents in the water may bring into solution further otherwise insoluble amounts of barium.

Additional limiting concentration values have been similarly calculated for a few inorganic substances for most of which water standards have either been established or recommended (Table 2). The estimated safety factor in the present water standards is indicated with each of these values. The similarity of the calculated value and water standard for fluoride, on which the best evidence for water standards exists, should be noted. The calculated values for arsenic, selenium, and lead are 3–10 times the standard values. On the other hand, the value recommended by the USPHS for manganese (based on staining effects) shows wide divergence from the calculated value. The recognized lethality of cyanide to fish at very low concentrations probably accounts for the much lower standard established for this substance than that calculated.

Similar calculations have been made for a few types of organic compounds as shown in Table 3. Examination of this table shows the arresting fact that organic substances in general can be tolerated at far higher concentrations than most of the inorganic substances listed in Table 2. The detoxifying actions of the body render a wider variety of organic substances less injurious than they are capable of doing with inorganic substances. The calculated values indicate in several instances—for example, for acrylonitrile and methylchloroform—that the concentrations expected to produce no effect in healthy adults may approximate several hundred parts per million and even several thousand (as for acetone) in the drinking water.

Among the organic compounds, however, there are commonly a number of more important considerations in establishing safe limits than those of health. These considerations include taste, odor, color, and effects on treatment processes, and are usually less

TABLE 2

*Limits for Inorganic Substances in Water Calculated From Threshold Limits for Air**

Substance	Absorption Factor		Limit for Water† *ppm*	Threshold Limit for Air *ppm*	Estimated Safety Factor in Water Standard†
	Inhalation	Ingestion			
Arsenic	0.2	0.8	0.6	0.5	10
Barium	0.75	1.0	2.0	0.5	—
Cadmium	0.25	0.03	4.0	0.1	—
Chromium$^{(6+)}$	0.75	0.06	6.0	0.1	3–120
Cyanide	0.6	0.8	19.0	5.0	40–125
Fluoride	0.1	1.0	1.25	2.5	0
Lead	0.2	0.2	1.0	0.2	3–10
Manganese	0.1	0.2	15.0	6.0	3–>50
Selenium	0.8	0.8	0.5	0.1	10
Vanadium	0.5	0.5	2.5	0.5	—
Zinc	0.25	0.25	75.0	15.0	5–75

* All figures approximate.
† For healthy adult.

important for inorganic substances. It is certain, for example, that no one would base the drinking water standard for phenol on its health effects—which approximate a value of 95 ppm—when its chlorinated products produce undesirable taste and odor characteristics at a few parts per billion. Similar considerations apply to allyl alcohol whose odor threshold is reported to be 0.017 ppm. On the other hand, aniline has no appreciable taste or odor below 200 ppm and the calculated value of 50 ppm gives some reasonable assurance of freedom from health effects in healthy adults. Further consideration would have to be given to factors other than health before a final value could be selected.

TABLE 3

*Limits for Organic Substances in Water Calculated From Threshold Limits for Air**

Organic Compound	Absorption Factor		Limit for Water *ppm*	Threshold Limit for Air *mg/cu m*
	Inhalation	Ingestion		
Acetone	0.5	1.0	6,000	1,000
Acrylonitrile	0.75	0.85	240	20
Allyl alcohol	0.75	0.8	55	5
Aniline	0.5	1.0	47	5
Benzene	0.35	0.4	340	25
Carbon tetrachloride	0.3	0.5	480	25
Ethylenediamine	0.75	0.8	140	10
Formaldehyde	0.8	0.8	30	5
Methyl bromide	0.3	0.5	240	10
Methylchloroform	0.1	0.5	2,700	500
Phenol	1.0	1.0	95	5
Pyridine	0.1	0.5	30	10

* All figures approximate.

Absorption Factors

Probably the greatest uncertainty in calculating the limits for a substance in water lies in the choice of absorption factors in inhalation and ingestion. Simple calculations show that a limiting value a few times larger or smaller may result from the absorption factors selected. The uncertainty arises from the fact that, for the relatively low concentrations in question, exact data on absorption by inhalation and ingestion in man or in animals are either nonexistent or only rough approximations. Therefore, estimates of the magnitude of these factors must be made, in many instances, on toxicologic judgment. Limiting values, based on absorption factors possessing some uncertainty may be compensated for by including a larger safety factor in the final value. Lest the outlook be too gloomy, it should be pointed out that accurate absorption factors are known for certain substances—for example, by ingestion, cadmium, chromium, and certain lead compounds and, by inhalation, many of the organic compounds listed: acetone, benzene, and carbon tetrachloride. From these known values and from the chemical structure and physical properties—such as solubility and vapor pressure—of those substances whose

absorption factor is not known, a reasonably good estimate may be made.

Use of Pesticide Tolerances

Also valuable in developing drinking water standards are the chronic toxicity data of the pharmacology division of the Food and Drug Administration on food are developed does not permit immediate adaptation to water standards. Toxicologic considerations are not the sole basis by which the liquids are established.

The Food and Drug Administration follows the principle that no tolerance level will be established that is higher

TABLE 4

Relative Toxicities for Man of Inorganic Substances As Industrial Water Wastes

Substance	Toxicity*		Substance	Toxicity		Substance	Toxicity	
	Acute	Chronic		Acute	Chronic		Acute	Chronic
Aluminum	Mild	Un	Gold	Sev	Sev	Selenium	Un	Mild
Ammonium	Mild	Un	Indium	Mild	Mild	Selenates	Mod	Sev
Antimony	Mod	Sev	Iodide	Sev	Sev	Selenites	Mod	Sev
Arsenic	Sev	Sev	Iron	Sev	Un	Silicon	Un	Un
Barium	Sev	Un	Lanthanum	Mod	Mod	Silver	Mod	Mod
Beryllium	Sev	Sev	Lead	Mild	Sev	Sodium	Un	Un
Bismuth	Mod	Mod	Lithium	Sev	Sev	Strontium	Un	Un
Borates	Sev†	Mod	Magnesium	Mild	Un	Sulfur	Un	Un
Bromate	Sev	Sev	Manganese	Un	Sev	Sulfates	Un	Un
Bromide	Mild	Mod	Mercury	Sev	Sev	Sulfites	Un	Un
Cadmium	Mod	Sev	Molybdenum	Mild	Un	Tantalum	Un	Un
Calcium	Un	Un	Nickel	Mild	Sev	Tellurates	Mod	Sev
Cerium	Mod	Mod	Nitrate	Sev†	Un	Tellurites	Mod	Sev
Cesium	Sev	Un	Nitrite	Sev†	Un	Thallium	Sev	Sev
Chlorate	Sev	Sev	Osmium	Sev	Un	Thorium	Mild	Sev
Chromium	Mild	Sev	Palladium	Mild	Mild	Tin	Mild	Mild
Cobalt	Mild	Sev	Phosphorous‡	Sev	Sev	Titanium	Un	Un
Copper	Mild	Mild	Phosphates	Mild	Mild	Tungsten	Mild	Mild
Cyanide	Sev	Un	Platinum	Mod	Mod	Uranium	Mod	Mild
Fluoride	Sev	Sev	Potassium	Sev	Un	Vanadium	Sev	Mod
Gallium	Mild	Un	Radium	Un	Sev	Yttrium	Mild	Mild
Germanium	Mild	Un	Rubidium	Sev	Un	Zinc	Mild	Un
			Scandium	Mod	Mod	Zirconium	Mild	Un

* Key: Mild—Toxic effects of slight degree, such as gastrointestinal irritation; Mod (moderate)—Toxic effects of moderate to serious degree, such as injury to internal organs; Sev (severe)—Seriously debilitating effects that may end in death; Un (unimportant)—Substance essentially nontoxic or of no toxicologic concern because of reactions in water or for other reasons.
† In infants.
‡ Yellow.

tration. A comparison of the substances for which this agency has set food tolerances for pesticide residues with those in the threshold limits list shows a listing of approximately 90 additional substances.

Unfortunately, the basis on which tolerance limits for pesticide residues than is reasonably necessary under normal conditions of use. Levels, therefore, in many instances, may be below the level permitted on a health basis.

In addition to its work on pesticide residues, the Food and Drug Administration continuously conducts toxicity

studies to prevent the use of harmful substances in foods, drugs, and cosmetics. Results of many of the studies are reported in independent scientific journals, and members of the administration's pharmacology division consult freely with manufacturers who contemplate use of new ingredients. Because the studies on food deal extensively with oral toxicity they furnish direct data for the selection of suitable limiting concentrations for substances in water.

Nutritional Studies Data

A largely unconsidered source of oral toxicologic information for developing water standards is to be found in scientific reports of nutritional studies. It is common in such reports to find extensive toxicologic data dealing with the evidence in support of the noninjurious character of substances upon ingestion. Such information is to be found in such publications are the *Journal of Nutrition* and the American Medical Association's *Archives of Industrial Health.*

Toxicologic Classifications

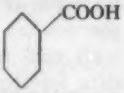
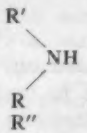
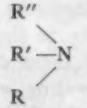
General classifications of all substances according to their toxicity are also valuable. In classifications such as are shown on Tables 4–6, each substance in which there is sufficient information to form a judgment or from which a judgment may be made from a closely related compound, is rated on an acute and chronic basis as to toxic hazard according to four categories which range from acute toxcity to the essentially nontoxic. Each of these categories may be assigned a limiting value based on the approximate dosage range for the group with which the substance is associated. For example, substances rated "severe" according to chronic toxicity standards may be assigned a limiting concentration in water of 1 ppm; "moderate," 10 ppm; "mild," 50 ppm; and "unimportant," 250 ppm.

For organic substances (Tables 5 and 6) the limiting concentrations for the corresponding toxicity categories tend to be correspondingly higher for reasons previously given. Thus, for the "severe" category, concentrations would be limited to 0–10 ppm, depending upon the degree of risk. Similarly, a higher limit might be assigned to the "moderate" category, putting it at 100 ppm. "Mild" would be 500 ppm and the "unimportant" category, a value of possibly 1,000–2,000 ppm. It is obvious that the far greater uncertainty attached to values obtained in this manner would limit their use to emergency situations only.

Toxicity classification on a chemical structure basis is confined to relatively simple substitutions of the basic chemical structure of the class—halogenation, for example, or nitration. With more complex structures, it is not possible to use this technique. A means out of the difficulty may be found if sufficient toxicity information is available on a series of structurally related, highly complex substances which are, in turn, related to the substances in question. Such closely related series of substances with complex structures are the surfactants, the principal types of which are illustrated in Table 6. It is shown, for example, that the anionic surfactants, as a group, are practically nontoxic. The alkyl aryl sulfonates are more toxic than other types of anionic surfactants. On the other hand, the quaternary nitrogen compounds, as a group, are highly toxic and limiting water concentrations would need to be set accordingly. As with the other

TABLE 5

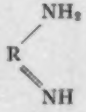
Toxicities of Classes of Organic Substances as Industrial Wastes

Class	Toxicity		General Formula
	Acute	Chronic	
Acids			
Aliphatic, saturated	Unimportant* (halogenated forms tend to be more toxic)	Unimportant	RCOOH
Aliphatic, unsaturated	Mild to Moderate	Unimportant	
Aromatic, monobasic	Mild to Moderate	Unimportant	
Aromatic, polybasic	Mild	Unimportant	
Acid amides†			
Aliphatic, saturated	Unimportant	Unimportant	$RC{=}ONH_2$
Aliphatic, unsaturated	Moderate	Severe (Acrylamide)	
Aromatic	Mild	Unimportant	
Alcohols			
Aliphatic, saturated (See also Glycols)	Mild (except methyl—severe) Toxicity decreases sharply from C_3 alcohols and beyond. Branched chain compounds tend to be more toxic	Unimportant	ROH
Unsaturated	Severe	Unimportant	
Aromatic	Severe	Moderate	
Aromatic, mono-	Halogenated nitro- and aminophenols tend to be more toxic		
Aromatic, poly-	Moderate	Unimportant	
Aldehydes			
Aliphatic, saturated	Mild to Moderate (halogenated derivatives tend to be more toxic)	Unimportant	RCHO
Aliphatic, saturated, poly-	Moderate to Severe	Unimportant	
Unsaturated	Moderate to Severe	Unimportant	
Aromatic	Mild	Unimportant	
Amines			
Aliphatic	Moderate	Unimportant	RNH_2
Aliphatic, primary	Toxicity increases with chain length		
Aliphatic, secondary	Increasing toxicity		
Aliphatic, tertiary and quaternary	Most toxic of group		
Diamines	Moderate to Severe	Unimportant	NH_2RNH_2

* Indicates substance essentially nontoxic or one which creates no toxicity problem because of its destruction in water or for other reasons. Other toxicity classifications defined as in Table 4.

† Some compounds of this class are potential carcinogens.

TABLE 5—*Toxicities of Classes of Organic Substances as Industrial Wastes (Contd.)*

Class	Toxicity		General Formula
	Acute	Chronic	
Amines†			
Aromatic, mono-	Moderate to Severe (nitration and halogenation tends to enhance toxicity)	Unimportant*	
Aromatic, poly-	Severe	Severe	
Amidines	Severe	Severe	
Cyanides (nitriles)			
Aliphatic, saturated	Moderate to Severe	Unimportant	RCN
Aliphatic, unsaturated	Severe	Severe (Acrylonitrile)	
Aromatic	Severe	Unimportant	
Esters			
Aliphatic	Mild to nontoxic	Unimportant	RC=OOR
Aromatic	Mild	Unimportant	
Mixed	Moderate to nontoxic	Unimportant	
Esters			
Aliphatic	Mild	Unimportant	ROR′
Aromatic and mixed	Mild	Unimportant	
Aromatic, poly-	Mild to nontoxic	Unimportant	
Glycols	Mild to nontoxic (except ethylene glycol—Severe)	Unimportant	HOR—ROH
Diglycols	Severe		
Diglycols, poly-	Mild to nontoxic	Unimportant	
Hydrocarbons			
Aliphatic, saturated	Mild to nontoxic Severe (some may act as cancer catalysts)	Unimportant	RCH_3R
Aliphatic, unsaturated	Mild	Unimportant	RCH=CHR′
Aromatic	Mild to Moderate (except benzene—Severe)	Severe	
Aromatic, poly-†	Unimportant	Severe	
Halogenated hydrocarbons			
Aliphatic, saturated	Moderate to Severe	Moderate to Severe	RX
Aliphatic, unsaturated	Severe (in general, toxicity increases in order Cl, Br, I)	Severe	RCH=CHX
Aromatic, mono-	Mild to Moderate	Unimportant	
Aromatic, poly-	Severe	Severe	

* Indicates substance essentially nontoxic or one which creates no toxicity problem because of its destruction in water or for other reasons. Other toxicity classifications defined as in Table 4.

TABLE 5—*Toxicities of Classes of Organic Substances as Industrial Wastes (Contd.)*

Class	Toxicity		General Formula
	Acute	Chronic	
Ketones			
Aliphatic, saturated	Mild (toxicity increases with molecular weight)	Unimportant*	RCOR′
Aliphatic, unsaturated	Moderate	Unimportant	
Aromatic	Mild to Moderate	Unimportant	
Mixed	Mild to Moderate (halogenation increases toxicity greatly)	Unimportant	
Nitro compounds			
Aliphatic, saturated, mono-	Moderate	Moderate	$R-NO_2$
Aliphatic, saturated, poly-	Severe	Severe	$R(NO_2)X$
Aromatic, mono-	Moderate	Severe	
Aromatic, poly-	Severe	Severe	
Thiols			
Aliphatic, saturated	Mild to Moderate (except t-octyl, thiol and benzene thiol—Severe)	Data not available	RSH
Aromatic	Severe		
Mixed	Moderate		

* Indicates substance essentially nontoxic or one which creates no toxicity problem because of its destruction in water or for other reasons. Other toxicity classifications defined as in Table 4.

classifications of this type, significant departures from the basic structure of the group should be excluded from toxicologic relationship with it.

It is obvious that the four broad toxicity categories provide only an approximate assignment of limiting concentrations; such a datum, however, may often be necessary for immediate control of a particular pollution problem. Tentative values of this sort may be modified, however, as additional evidence becomes available. As previously mentioned, the limits for a great number of organic compounds will not be dictated by toxicologic considerations, but will be based on unesthetic qualities imparted to the water by the organic substance.

Modifying Factors

Reflection on the factors underlying the concern for safe drinking water standards will reveal that they are far more numerous and complex than those involved in setting the threshold limits for air tolerances or for pesticide residues on foods. Limiting concentrations for substances in water supplies—just discussed—represent but the first step in the development of a water standard. Whereas the threshold limits for substances in air apply to adults of working age and of essentially robust health, drinking water standards apply, without exception, to all—young and old, sick and well. Even the considerations involved in the establishment of tolerances for toxic

substances associated with food are less rigid, as no food is consumed so universally and continuously as is water. On a toxicologic basis alone, there are several factors that would modify any limiting value calculated from toxicologic data. One factor arises from the fact that toxicologic data are most commonly derived from experiments on healthy adult animals or, occasionally, on man. Hence, the need to allow for possible increased toxicity because of extreme youth, age, or disease. The downward revision in the calculated value for the limiting concentration may be considerable—depending upon circumstances. For example, from what is known of the toxicity of drugs for infants (*7*) the dose for them is 20 to 1 per cent of the adult dose. In instances of this sort where the dosage reduction is known to be large because of toxicity, a commensurate reduction in the limiting water concentration must be made in order to arrive at an acceptable standard.

Chelating Agents

A type of substance which may give considerable concern with respect to augmented effects—if an already toxic metal is present in the water—is the chelating agent. Of many different chemical types structurally, chelating agents are organic compounds possessing groups which have the capacity to unite simultaneously with a metal in both an ionic and a covalent (nonionic) bond. The resultant metal organic complex then behaves toxicologically with altered potency—at times with seriously augmented effects. For example, it has been shown that the chelating agent ethylenediaminetetraacetic acid augments the poisonous effects of cadmium; on the other hand, the toxicity of lead ("lead poisoning") is reduced by the same agent. In general, however, the net physical effect of a chelating agent would be to solubilize insoluble metal inorganic compounds. An adverse situation could arise in a stream bearing an amount of toxic metal within acceptable standards. On mixtures with citric or tartaric acids from a food-processing plant, for example, the solubility of the metal might be so augmented that its otherwise acceptable concentration would become excessive.

Carcinogens

The question of the factor to be used to modify the limiting water concentrations of a known or potentially carcinogenic agent poses an almost insoluble problem at present. There are three chief reasons for this: [1] there is no chemical carcinogen for which the minimal dose for the lifetime of man is known. [2] What is or is not a carcinogen for man cannot be presently inferred from animal studies. (Accordingly, substances of possible carcinogenic activity may go unsuspected or others may be considered potential hazards when none exist.) [3] The role of cocarcinogenic substances ("cancer catalysts") and irritants as influences in the onset of carcinogenesis is far from clear. The presence of such substances in polluted streams would add imponderably to the difficulty of setting a satisfactory water standard for such substances. Permitting no measurable quantity of a carcinogenic agent in water would appear to be the only present means of dealing with such materials, but it is scarcely a practical one. Research should be stimulated in this area of cancer research to develop minimal tolerable doses of carcinogenic agents for man.

TABLE 6

Toxicities of Principal Types of Surfactants

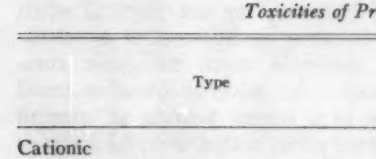
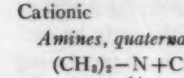
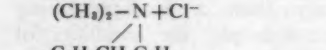
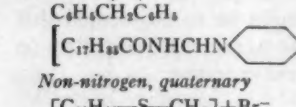
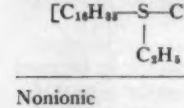
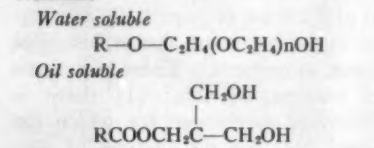
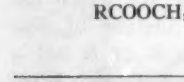
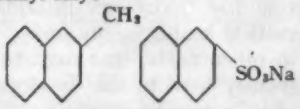
Type	Toxicity	
	Acute	Chronic
Cationic *Amines, quaternary*  *Non-nitrogen, quaternary* 	Severe (oral lethal dose for animals, generally below 1 g/kg. Some exceptions with lower toxicity)	Severe (at less than 0.1 per cent in diet
Nonionic *Water soluble*  *Oil soluble* 	Moderate (oral lethal dose for animals, 2–7 g/kg)	
Ampholyte 	Mild	
Anionic *Carboxy acids (natural)* Rosin:  Fatty acids: R—COONa *Synthetic (acid amines)* 	Practically nontoxic (oral lethal dose for animals, 12–>40 g/kg)	Mild to Moderate (applies to sulfonates only)

TABLE 6—*Toxicities of Principal Types of Surfactants (contd.)*

Type	Toxicity	
	Acute	Chronic
Sulfuric esters Sulfonated Oils: R—OSO_3Na (Straight and branched chain)	Practically nontoxic (oral lethal dose for animals, 12–>40 g/kg)	Mild to Moderate
Sulfonates Alkyl: R—SO_3Na Alkyl only:  		

On the other hand, there are a few substances known to have carcinogenic potentials for man. For such it is recommended that their presence in drinking water be kept at the lowest possible level and, if necessary, that other sources of water be provided.

Mixtures

A problem equally vexing, but less difficult of solution, is the control of pollutant mixtures. Actually this is the entire problem, for it is becoming increasingly rare that one chemical alone is responsible for stream contamination. There are yet no general toxicologic rules for assessing *a priori* the hazard of any known mixture; each has to be evaluated experimentally according to its particular composition. Whenever the question of toxicity of mixtures arises, so immediately does the question of intensification and diminution of toxic effects. With regard to this, the view at the present time is as follows: Although the number of chemical combinations producing an intensifying effect continue to multiply, the number of unequivocally proved instances of true intensification remains relatively small. The latter involve certain mixtures of organic phosphate pesticides, some organic solvents and alcohol, and—of little pertinence here—mixtures of certain respiratory irritants. In a toxicity test of more than 20 substances in more than 200 combinations, instances of either synergy or antagonism were rarely found (*8*). Other isolated instances where careful tests have been made, have similarly shown that only additive effects result, with no evidence of intensification. In one instance (*9*) an eight-component mixture of solvents—chiefly oxygenated aliphatic compounds—was involved; in the other (*10*), a three-component mixture of halogenated hydrocarbons. It has recently been found, also, that the intensification among the organic phosphates is of practical importance only in acute exposures; it is of no practical importance in chronic long-term exposures. Thus, additive effects are the rule and synergism and antagonism among combinations, the exception.

In this connection, it would seem wise to establish permissible level of organic substances irrespective of toxicity, in much the same way that the present USPHS Drinking Water

Standards recommend limits for total solids. This would serve as a deterrent to continuing increases in pollution of water sources with organic materials.

Conclusion

Toxicologic considerations, although important, are only one factor in developing drinking water standards. A few of the other factors such as taste and odor, staining properties, and other aesthetic considerations, have already been mentioned.

In addition, the effect of the water on vegetation and on fish deserves consideration since drinking water is extensively used on plants and in aquaria. For such substances as boron and some pesticides, the sensitivity of plants and fish may be much greater than that of man.

A further consideration is that of feasibility. The fact that a substance may be nontoxic and otherwise innocuous in concentrations of 200 ppm does not imply that it is a desirable constituent of drinking water. Consequently, standards should continue to embrace the principle that drinking water should contain as high a percentage of water as feasible and that materials should not be added to it indiscriminately.

The USPHS Drinking Water Standard was last revised in 1946 and this version differs only slightly from the 1942 edition. The past 15 years have seen the emergence of the atomic age and the greatest increase in industrial activity ever experienced in this country. New water quality problems accompanying these changes call for a review of the present drinking water standards. It would be desirable if this review could be placed on a continuing basis in view of the rapidity with which new water quality problems are arising.

Summary

A basis for an approach to the increasingly complex problem of developing drinking water standards is presented. It is limited chiefly to toxicologic or health considerations.

Attention is drawn to a rather large background of toxicologic information and practical health safetly limits, now used in other fields, that may be advantageously used in the development of drinking water standards.

Discussed are: [1] safe limits of toxic substances in the air of industrial environments—the so-called threshold limits or maximal acceptable concentration values, [2] toxicologic information on which pesticide residue tolerances for foods are based, [3] toxicologic information developed from nutritional studies, and [4] toxicity classifications based on chemical structure relationships.

Considerable discussion is given to a variety of modifying factors that must subsequently be applied in developing a tentative standard for water—which demands more stringent requirements than the subjects of other existing health standards. Major factors of concern are the difference of susceptibility of the very young, the aged, and debilitated individuals; carcinogenic agents; and the possible modification of toxic response as a result of combinations of substances.

It is pointed out that intensified or diminished effects of combinations are apparently not common but, rather, that the response more usually is additive. Where intensification is recognized, safety factors can be included in the final standard as for other modifying factors. Chelation of metals with

certain organic contaminants of streams seems to present equally great possibilities of augmented toxicity.

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Correction

The portion of the panel discussion, "Selection of Meters and Services," by Charles Floyd Jr. (February 1958 JOURNAL, Vol. 50, pp. 247–250) contained an editorial error. The charts shown for Fig. 1 (p. 248) and Fig. 2 (p. 249) were transposed. That on p. 249 should appear as Fig. 1, "Head Loss Through Meters," and the drawing on p. 248 should accompany the caption of Fig. 2, "Head Loss Through Full Service Lines."

Simplified Fluoride Distillation Method

Ervin Bellack

A paper presented on Nov. 1, 1957, at the Chesapeake Section Meeting, Washington, D.C., by Ervin Bellack, Chemist, Div. of Dental Public Health, USPHS, Bethesda, Md.

THE basic technology of fluoride distillation has been little changed since Willard and Winter (*1*) reported it in 1933. Many of the conditions of distillation, including both mechanical and chemical considerations, have been thoroughly studied by a number of investigators (*2, 3*). Several modifications have been suggested with the aim of providing greater ease or less time consumption in the distillation process; among these is the use of temperature-controlling devices and compressed air to replace the steam or distilled water normally used to drive over the fluoride (*4–6*).

In spite of the improvements, the method remains somewhat cumbersome, requiring elaborate apparatus and considerable attention and skill on the part of the user. Among the drawbacks most commonly encountered are dilution of the sample and the need for careful temperature regulation during the period when steam is being introduced into the distilling flask. Some modifications (*4–6*) purport to eliminate these difficulties, but actually introduce further complications in the form of still more involved apparatus. The control of air flow rate, for example, with the pronounced effect on acid carryover and fluoride recovery, is extremely critical.

Ideal Method

The ideal distillation method would be one in which there were neither steam nor compressed air used, no dilution of the water sample encountered, and no regulation of temperature required. In addition, the acid used would be one which introduced no hazard and produced no volatile ions which would interfere with the subsequent fluoride analysis. With this ideal in mind, studies were begun on an improved method which would meet some—if not all—of these requirements.

Among the contemplated improvements were the substitution of another high boiling–point acid for sulfuric or perchloric acids and the use of vacuum instead of steam or air to drive over the fluoride. Of the various materials tried as acid substitutes, only ammonium bisulfate gave any measure of promise. The temperature required to give complete recovery of fluoride was so high, however, that sulfate carryover was beyond the tolerable range and the possibility of volatilizing interfering ions was enhanced. Using an aspirator-induced air stream through the distillation flask introduced another problem—the loss of fluoride through the vacuum system. Because the possibility of finding a distillation method

which would be suitable for use with such sulfate-sensitive analytical procedures as that of Megregian (*7*) seemed very unlikely, attention was diverted to a procedure which would be compatible with the *Standard Methods* analyses (*8*). Although the restrictions regarding the acid could then be relaxed somewhat, the remaining points of the ideal distillation method could conceivably be met.

The method was to be based on the principle of distilling a fixed volume from a particular sulfuric acid–water mixture so that a fixed volume of distillate would be recovered. Thus, the only control to be required of the operator was the shutting off of the still when the volume of distillate equaled the volume of sample placed in the still originally.

The remaining problem, then, was determination of the volume of acid to be employed in order to attain complete recovery of fluoride in the distillate without contamination from volatile anions.

Investigation

The study of these unknown factors was begun by investigating the disclosure by Megregian and Solet (*2*) that at least 100 ml of distillate must be recovered at the optimum temperature range of 130°–150°C. The apparatus used consisted simply of a distilling flask, a connecting tube, and a condenser. A thermometer and the necessary adapter were included merely in order to check the progress of the distillation (Fig. 1). A sulfuric acid–water mixture was prepared so that, when a 150-ml sample was distilled, the temperature conditions would be met. Unfortunately, under these conditions, recovery of fluoride in the distillate was found to be only approximately 60 per cent. Increasing the sample volume produced an increase in the recovery, but, as can be seen from the figures below, the law of diminishing returns seems to be in effect and, although an infinitely large sample would guarantee virtually complete fluoride recovery, the procedure will then have gone beyond the bounds of practicality.

Sample Volume *ml*	Fluoride Recovered *per cent*
200	68
250	77
300	84
350	90
400	94

Obviously, then, the conditions of temperature range which apply to conventional steam distillation do not apply here. In order to modify the temperature range, the ratio of acid to water was gradually increased, with a corresponding increase in boiling point, until further increases failed to improve the fluoride recovery. The boiling point at this stage of the experiment was 180°C and the ratio of acid to water was 2:1.

Boiling Point of Mixture °C	Fluoride Recovered in 200 ml of Distillate *per cent*
155	80
160	85
165	88
170	91
175	93
180	94

Increasing the volume of the acid-water mixture so that 150 ml of distillate was recovered above 130°C resulted in a rise in the recovery to 96

TABLE 1

Results of Distillation of Water Samples Containing Fluoride or Fluoride and Interfering Ions

Number	Composition of Sample			Fluoride Recovered mg/l	Mean Fluoride Recovery and Deviation mg/l
	Fluoride mg/l	Other (Interfering Ions)			
		Substance	Amount—mg/l		
1	1.25	Aluminum	2.5	1.27 1.22 1.23	1.24 ± 0.02
2	0.75	Hexametaphosphate	2.5	0.79 0.73 0.77	0.76 ± 0.03
3	2.00	Hexametaphosphate	10.0	2.07 2.02 2.04	2.04 ± 0.05
4	1.00	Aluminum	10.0	1.02 1.00 1.00	1.01 ± 0.01
5	1.20	Aluminum	2.5	1.31 1.27 1.24	1.27 ± 0.03
6	0.75	Hexametaphosphate	7.5	0.80 0.71 0.76	0.76 ± 0.04
7	0.50	—	—	0.51 0.49 0.49	0.50 ± 0.01
8	3.00	—	—	2.88 2.94 2.92	2.91 ± 0.09
9	0.09	Hexametaphosphate Sulfate	5.0 500.0	0.10 0.08 0.10	0.09 ± 0.01
10	10.0	—	—	9.80 9.60 9.70	9.70 ± 0.30
11	0.20	—	—	0.23 0.21 0.21	0.22 ± 0.02
12	0.95	Aluminum	20.0	0.97 0.95 0.92	0.95 ± 0.02

TABLE 1—*Continued*

Number	Composition of Sample			Fluoride Recovered *mg/l*	Mean Fluoride Recovery and Deviation *mg/l*
	Fluoride *mg/l*	Other (Interfering Ions)			
		Substance	Amount—*mg/l*		
13	1.10	Aluminum	50.0	1.08 1.10 1.10	1.09 ± 0.01
14	0.85	Hexametaphosphate	25.0	0.88 0.85 0.87	0.87 ± 0.02
15	0.75	Phosphate	37.5	0.81 0.78 0.79	0.79 ± 0.04
16	0.22	Phosphate	50.0	0.24 0.23 0.23	0.23 ± 0.01

per cent, but further increases in the volume of the acid failed to improve recovery and, in some instances, actually lowered it. It was next demonstrated, by means of gradual increases, that 300 ml was the minimum volume of sample with which 100 per cent recovery was attainable.

Up to this point, all samples distilled were standard solutions of 1 mg fluoride per liter of distilled water. Before the method could be seriously considered, the amount of sulfate carryover during the distillation and the amount of fluoride capable of being recovered from waters of varying fluoride levels had to be determined. The problem of contamination of successive samples when the acid mixture is reused had to be solved and the effect of volatile anions, the effect of ions which might retard recovery, and the limits of the distillation rate had to be determined.

To ascertain the amount of sulfate carryover, a series of distillates were checked and found to contain less than 40 mg/l in any sample—with about 30 mg/l being most typical. This would then permit the use of any of the standard fluoride methods (*8*) with practically no sulfate interference. For recovery information, a number of water samples—some containing interfering ions—were distilled in triplicate. Results indicated that fluoride recovery was virtually complete on all samples, regardless of fluoride level (Table 1). This series of samples, although intended to demonstrate fluoride recovery at different levels, also serves to indicate the lack of interference from ions which normally would affect the fluoride determination. Thus, aluminum in as high a concentration as 50 mg/l, hexametaphosphate to 25 mg/l, and phosphate to 50 mg/l, do not interfere with fluoride determination in the distillate. The lack of contamination from successive samples of different fluoride levels can also be shown here because the samples were run in

the order indicated without changing acid or flushing the still. The only exception to this occurred following Sample 10, which contained 10 mg/l fluoride. It was found necessary to flush out the still with distilled water before the next sample when a trial low-fluoride sample, distilled without prior flushing, produced results approximately 0.1 mg/l too high. It can be seen, however, that samples with as high as 3.0 mg/l fluoride can be distilled without fear of contaminating the following sample.

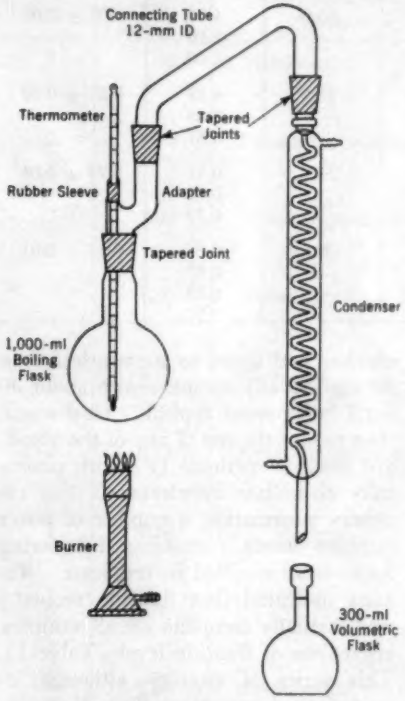

Fig. 1. Distillation Apparatus

Thermometer and adapter may be omitted in routine procedure.

Further tests indicated that up to 300 mg/l aluminum (90 mg in the sample), 400 mg/l silicon dioxide as colloidal silica (120 mg in the sample), and 300 mg/l silicon dioxide as silicate (90 mg in the sample) did not retard the recovery of fluoride. As could be expected, the effect of large quantities of chloride caused interference in the analysis, but the use of silver sulfate in the distilling flask at a proportion of 5 mg/mg of chloride effectively reduced to a minimum the hydrochloric acid carryover into the distillate.

The time required for distillation proved to be simply a matter of the efficiency of the condenser and the capacity of the burner. The usual amount of time consumed in distilling a 300-ml sample was 15–20 min. By using two burners, the distillation time could be reduced to as little as 10 min, although by doing so the sulfate carryover was increased somewhat.

Apparatus

The original apparatus * design proved to be quite satisfactory and any modification would have to be carefully considered. The primary con-

* Apparatus used: one 1-liter, round-bottom, long-neck, pyrex boiling flask (standard taper joint, 24–40 mm); connecting tube (joints as in the preceding item); one long, efficient Graham condenser; one receiver calibrated at 300 ml; one thermometer with scale to 200°C and adapter, both of which may be omitted for routine use; and one burner. All apparatus was manufactured by Corning Glass Works, Corning, N.Y., except the receiver which is a product of the Arthur H. Thomas Co., Philadelphia, and the thermometer and burner, both products of the Fisher Scientific Co., Pittsburgh, Pa.

siderations are based on conditions which could affect the complete recovery of fluoride—such as obstruction in the vapor path, trapping of liquid in the adapters and condenser, and conditions which might enhance sulfate carryover.

Procedure

The procedure for the distillation is as follows: Place 400 ml distilled water, 200 ml concentrated sulfuric acid, and 2–3 dozen glass beads in the distilling flask and swirl to mix. Connect the apparatus as shown in Fig. 1, making sure all joints are tight. Begin heating slowly at first, then as rapidly as the efficiency of the condenser will permit (distillate must be cool). Heat until the temperature of the flask contents reaches 180°C. At this point, the apparatus has been flushed out and the acid-water ratio has been adjusted. As soon as the flask contents cool to 120°C—in about 20 min—the apparatus is ready for the sample. Exactly 300 ml of sample is added to the flask, mixed, and the distillation carried out as before until exactly 300 ml of distillate is recovered.

Occasional checking of the temperature at the end of the distillation will serve to verify the accuracy of measurement of the sample and distillate. The thermometer need not be used routinely once the operator is sure that the distillation ends at 180°C each time. The still need not be flushed out except when samples containing more than 3.0 ppm of fluoride have been distilled. At those times, a 300-ml portion of distilled water should be distilled through the apparatus to prevent contamination of successive low-fluoride samples.

The acid need not be replaced until the accumulation of ions causes carryover of interferences or retards fluoride recovery. An accumulation of 300 mg of aluminum or 300 mg of silicion dioxide as silicate will affect subsequent fluoride recovery. An occasional recovery check with standard fluoride samples will indicate when the acid is to be replaced. When fresh acid is used, the procedure outlined at the beginning of this section should be followed. When water samples with high chloride content are to be distilled, silver sulfate, in the proportion 5 mg/mg of chloride, should be added to the distilling flask.

Conclusion

A distillation method for fluoride has been found which requires neither steam nor compressed air and in which no dilution of the water sample is encountered. The principle involved is the distillation of a volume of water sample from a particular sulfuric acid mixture so that the same volume of distillate—with full fluoride recovery—is obtained. The method is simple, requires only standard items of apparatus, and consumes very little time.

Acknowledgment

The assistance provided by Paul J. Schouboe in the distillation and analysis of water samples is gratefully acknowledged.

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Electronic Accounting in Public Utilities

Frank Twohy

A paper presented on Nov. 1, 1957, at the California Section Meeting, San Jose, Calif., by Frank Twohy, Controller, Dept. of Water & Power, Los Angeles, Calif.

MANY speeches and papers that have been presented in the past several years on electronics and its position in the business world are overrun with platitudes. Therefore, this article will be confined to a review of some of the things that have actually occurred in the field of office automation, without attempting to make predictions of future developments.

First, it should be understood that there are many types of electronic devices made and, fundamentally, all of them are truly engineering marvels. Basically there are three types of electronic digital computers—small, intermediate, and large.

Small and Intermediate

The small equipment has been available for over 10 years and was originally referred to as an electronic multiplier. Punched-card equipment included multiplying equipment long before World War II. Such equipment had counter wheels, but gained its speed by registering left-hand components and right-hand components of calculations in separate counters, so that all digits of the multiplicand could be calculated simultaneously with the last cycle of the process, consisting of bringing the left-hand and right-hand components together in a single counter.

During the war, tremendous progress was made in the field of high-speed electronic calculation by the use of vacuum tubes and a binary system of recording. The development of tubes which could emit and receive impulses at astounding rates of speed (for example, 200,000 per second) with dependable accuracy was the key that unlocked the door to high speed calculation. As a consequence, the first small electronic computers were equipped with up to 2,000 vacuum tubes and the production of calculations by punched card was increased from a range of five to twenty tabulating cards per minute to a fixed 100 cards per minute. There are thousands of these small devices in use and, although the office procedure experts spend a lot of time describing the unfound capabilities of the large machines, it is the author's opinion that the misunderstanding and underestimation of the capability of the electronic multiplying punch is probably costing business and industry huge sums. In other words, there are a number of intermediate-type electronic computers being applied to jobs which the electronic multiplier can handle, and for which proper time schedules would not be sacrificed. Obviously, a machine which leases for $500–$600 per month will have neither the speed

nor the capacity of a machine which leases for $4,000 per month. It is certainly true, however, that there are many procedures in office work which require neither the speed nor the capacity of the intermediate or the large equipment.

When procedures become so voluminous or complex that the speed and capacity of the small equipment is ineffectual, the intermediate size properly comes into good use. Intermediate size refers to the type of equipment that leases for approximately $4,000 per month. Again, many jobs are being performed on the large equipment which might be performed more economically on the intermediate equipment. In this regard, it is significant that manufacturers are now adding peripheral equipment to the intermediate installations, consisting of tape or other magnetic types of memory, as well as other read-in and read-out mechanisms. With the addition of this peripheral equipment to the intermediate type, inasmuch as accounting formulae are not as complex as those used in designing a guided missile, the computing speed and the recording ability of the intermediate size is usually more than adequate for most accounting purposes.

Large Equipment

Large equipment is that which leases for $20,000 and more per month and sells in the million-dollar area. This equipment is what is usually referred to as the giant brain, and there is just no doubt as to its speed and capacity being practically fantastic. This speed and capacity is absolutely essential for the really complex engineering work required in the twentieth century, and in making engineering calculations the capacities for calculation and retention of data are put to excellent use, but the presence of the capacities of memory has lured many accountants into feeling that an accounting procedure must use all of these capacities. In other words, whereas it is necessary to retain every facet of data respecting scientific calculations in order to arrive at the correct answer to a scientific problem, it certainly is not necessary to process through a machine an account number, a name, an address, a meter number, a record of meter tests made, a record of cash payments made, and other records covering an extended period of time if it is merely necessary to calculate the value of the current month's bill.

Successful installations of large equipment for strictly accounting procedures are hard to find. No doubt there are many good reasons for this, but failures radiate from two important points. The manufacturer and the systems and procedures experts have spent many years telling each other and the public that it is necessary to plan far ahead with absolute completeness and that all businesses must have a programming staff. Too many firms have believed that, first it must have a scientist or an engineer in charge of any project and, secondly, that the larger the staff involved, the more complete will be the planning. Every organization of any consequential size should have one or more persons working on procedures, but not to the point where there are more people working on procedures than necessary to make the procedure itself operate.

Misapplications

John Diebold, president of a management-consulting firm, wrote an

article (*1*) in which he gave examples of the misuse of electronic procedures:

> One of the major utility companies, after 2 years of preparation and 1 year after installation of a large-scale computer, announced publicly that they had underestimated the running time of their daily billing cycle and were forced to scrap their programs, return the machine, and start over with a new one.
>
> The first, and widely publicized, computer applied to a manufacturing operation required close to 2 years' additional preparation time before it began to handle productive work.
>
> One of the major insurance companies, with approximatelyy 200 people in its electronics research department, found after installation of their first computer that it took 1 year longer than expected to produce its first hour of productive work.

Diebold also stated, "management assumption that an engineer or scientist must handle office automation is erroneous." The result of this assumption has been a mad search for skilled scientific personnel. The demand created for so-called experts in the field has given rise to a large group of job hoppers who would be considered floaters in any other field. Giving themselves impressive job titles and going through several employers in a few years, these floaters have probably done more to set back office automation than anything else. Upon lighting with a firm, they immediately promote a staff and the next months, even years, are spent in staff and committee meetings wherein they flit from cloud to cloud and never really accomplish anything.

Nonetheless, the author firmly believes that electronic devices are going to play more and more important and impressive roles in accounting and office work. There was skepticism and many failures in the punched-card field 25–30 years ago, and the failures then radiated from the same two misunderstandings: that it was necessary to import a scientific person, and that a large staff was required to plan procedures. Experience has shown, however, that the successful jobs are planned and installed by personnel from within the organization, and that the effectiveness or economy of procedures is in inverse proportion to the size of the procedures staff.

A number of utilities are presently using electronic equipment of the intermediate size to quite good effect. A smaller number, because of the volume requirement, are now beginning to get somewhere with their larger equipment. No basic application has been discovered or made, however, which would have the universal basic application feature which attended the introduction of punched cards to public utility billing in the early 1930's. That such a basic application will be found is inevitable. Meantime, sensationally overenthusiastic claims about savings have put quite a dent in the profits of many organizations. There also has been too much of "keeping up with the Joneses" in this field in that, all of a sudden, the president of a large corporation, upon hearing that other corporations are acquiring large electronic devices, steps out and buys one.

Los Angeles Experience

The Los Angeles Department of Water and Power was the first utility to use punched cards for calculating the amount of the bill, making the bill, and keeping the accounts-receivable record, starting in 1926. It progressively installed punched-card proce-

dures throughout the rest of the account procedures. As of today, it is using the same basic punched-card system for customers' accounting, with only those changes which attended the availability of better equipment from the standpoint of speed, flexibility, and capacity. As an illustration, the columnar and counter capacity of the equipment 30 years ago was such that it was necessary to tabulate cards several times in order to produce the records needed. With the continued improvement of the equipment, it is now possible to combine several tabulations into just one.

With respect to payroll, the utility has converted this procedure from the punched-card system of sorting to various sequences—tabulating, preparing summary cards, and extending them for subsequent tabulations and accumulations—to a single processing step through the intermediate size electronic device, which has a magnetic drum for storage. In this regard, it should be noted that the former procedure for preparing payrolls and procuring the punched card paycheck required 31 control panels for various types of punched card equipment. It took approximately 170 hr of machine time and 100 hr of operator time each pay period to perform this function, which in itself was a great advance from the old, manual method of payroll and paycheck preparation. By changing slightly the coding of the cards punched from the time-recording documents, with no change in the preparation of the document itself, a single processing through the electronic device performs every function performed by the previous system in only 12 hr of machine time with 12 hr of operator time.

It should be emphasized that the utility studied payroll applications, after hearing of the magnetic-drum machine and seeing it demonstrated by the manufacturer, and made a few test programs for just parts of the procedure before deciding that a payroll procedure to save time and money was possible; but it did not create a large staff of programmers. First one man, the man in charge of the punched-card system, then his assistant, and then a technician took courses in programming. The technician, under the immediate guidance of these two superiors, did all of the programming work. On the second day after receiving the new machine, personnel started processing a payroll period under the old system, to try out the new system as a duplicate run to see how well they had planned. From 30 different payrolls, they selected an easy one and a difficult one to compare the two processes, and in each one, the magnetic-drum device worked well. Although they had anticipated duplicating of payroll procedures for a period of time before the new system worked smoothly, they never duplicated any but the first two payrolls, and starting with that first pay period and to this date, every payroll has been made under the new electronic procedure.

Prior to the receipt of the machine, accounting personnel started programming for transportation costs, distributions, allocations, and depreciation, functions which were also on standard punched-card routines. The experience in changing over to the new procedure for this was identical with the payroll, in that no difficulties were encountered and it was not necessary to duplicate any processes.

The third procedure for which they had planned was the distribution of labor charges. Again, the experience was the same. Without having to duplicate any records, they put the job on the intermediate electronic device, and it worked perfectly.

Cost estimates turned out exceptionally well. When deciding to order the device, personnel had calculated the amount of time required for the various processes, added 75 per cent for a safety factor, and concluded that, with a 40–50 per cent load factor on the electronic device, it would save money. In other words, if it were working almost half time, the reduction in the cost of doing the work under the new process would pay for the cost of the equipment and the staff operating it. The experience was that too much time had been allowed for safety factor and, actually the machine began to pay for itself around the 30 per cent load factor point.

Extended Use

Since receiving the machine, the utility has used it for the three basic jobs referred to on regular routines and has extended its use in the customer accounting field in that area where rate schedules are quite complex. It has not been applied to customer accounting as a complete process, because personnel are still searching for the ideal procedure, which they anticipate finding by continued experimentation.

When punched cards were first introduced, the greatest difficulty was to get personnel to understand that this was a new medium and that, in supplanting an old system, it was not necessary to do everything the old system did. This does not simply mean that systems become cumbersome by collecting extraneous matters from time to time, but also that all systems contain information which is part of the system by nature. For example, for years the staff had been listing cash payments, and it was difficult to convince the bookkeeping staff that they were not going to be listed any more. Under the old key-driven adding machine system, it really did not matter whether they were listed or not. It took the same amount of time on the manual adding machine to get the total, meter book by meter book, and as long as it took no more time, it was just as convenient to have a detailed listing of the payments, as the cost of the paper was relatively negligible. When converting to the punched-card system, however, personnel could list the payments at 75 per minute, or just add them and total them by meter book number at 120 per minute.

Another illustration of this theory is in the field of transportation. Many people drive automobiles to work, leaving the house, driving to a corner, making a turn, following streets, making other turns, and so forth, finally arriving where the vehicle is parked. When methods of transportation are changed from an automobile to a helicopter, for example, it will be absolutely unnecessary to follow the streets used in getting to a destination by automobile; not only unnecessary, it would be foolish. Obviously, the thing to do will be to get in the helicopter and go in a straight line to a destination. Therefore, in the Los Angeles utility department, in changing a system, the first thing is to analyze the present system to find out what parts of it are there because of the system itself, so that personnel do not design a new system which perpetuates gathering

data of no real use or value, which were gathered at no cost as a byproduct of the type of system previously employed.

An interesting application of the magnetic-drum device came about because of a recently enacted fuel cost adjustment provision in the electric rate ordinance which provided that, commencing with the effective date, kilowatt-hours would be prorated by day until the completion of the billing cycle, when all kilowatt-hours used would be subject to the fuel cost adjustment increment. As stated before, customer accounting is on punched cards, with gang punching from master cards for the larger groupings of similar use, by kilowatt-hour for electricity, and by hundred cubic feet for water. The number of master cards used approximates 2,000, covering perhaps 85 per cent of all the bills made. By calculating a time increment factor for each billing cycle subsequent to the effective date of the fuel cost adjustment, the 2,000 master cards are processed through the new electronic device and prepared for each succeeding day's billing cycles. Under any other system, the job would be of considerable difficulty and magnitude, while it is done almost casually under the machine system.

Future Prospects

It is the intention to continue putting routines on the intermediate size equipment to its highest proper load factor. As of now, the utility is saving money by having the equipment applied as far as it has been applied, and it was ordered at the approximate breakover point in cost, in order to get the advantage of certain more speedy and economical processes without having to design too many procedures in advance of receipt of the machine. It will probably be possible to do all of the accounting with intermediate equipment, although personnel are not overlooking the capabilities of the large equipment. Peripheral equipment has been designed and is now becoming available, which indicates that fundamentally the intermediate size computer element may be able to substitute for the large computer element, for accounting. If this is going to be possible, the savings, with the peripheral equipment needed by both at equal cost, will be in ratio to the cost of the intermediate computer element only, compared to the cost of the computer element only of the large size equipment.

Electronic equipment is going to be used more and more in office work. The people who have pioneered in this field to this time deserve a lot of credit for their accomplishments, even those who have had unfortunate experiences, because they will ultimately select procedures and routines which will save them time and money.

It is a foregone conclusion, however, that the transition to electronic offices will not be an overnight matter, even though it is going to be quite rapid. By comparison, the transition to this will be accomplished more speedily than the transition to punched cards from manually key-driven office equipment, which was, in turn, much faster than the transition from longhand bookkeeping to machine bookkeeping. Simply because people are more sophisticated now than people were 50

years ago, they are less apt to be fearful of change or awed by capabilities of machines than were their forebears. They are more progressive with regard to understanding possibilities and capabilities as contrasted with conditions of "the good old days." About the time that Sir George Stephenson was working on the invention of the railroad engine, a famous writer of the day stated, "What can be more palpably absurd than the prospect of locomotives driving twice as fast as horses?" Those who have seen crystal radios with earphones change to vacuum tube radios with loudspeakers and have seen the recent advent of television, as well as other great strides in communications and transportation, are certain to be more receptive to the marvelous possibilities which electronic accounting devices are making available.

Those in the public utility business, who occupy the unique position in the business world of performing the largest amounts of paperwork for a revenue dollar, will undoubtedly make the greatest strides in the application of these new devices to office routines. In these years, they are going to repeat the same kind of pioneering work done in the late 1920's and early 1930's in the application of punched cards to the eternal problem of finding the most speedy, efficient, and economical ways to process paper work.

Reference

1. Diebold, John. False Starts in Office Automation. *Management Review*, 46:81 (Jul. 1957).

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1957

A report of the activities of the Committee on Water Works Administration for the year ending Dec. 31, 1957, submitted to the AWWA Board of Directors on Jan. 26, 1958, by Wendell R. LaDue, Chairman.

AS outlined on pages 49–50 and 52–53 of the 1957 AWWA *Directory* (Reference Edition), the present organization of the coordinating Committee on Water Works Administration provides for 33 subcommittees grouped in four classifications, with over 135 members of the Association participating. The general committee consists of the chairman, the general chairmen of the four groups, and the chairmen of the various active subcommittees. Committee work has been broadened by the creation of "task groups," subordinate to standing committees. The chairman of a task group is not a member of the Committee on Water Works Administration, but, in general, works within the province of the division under which the task group functions. When the work of a task group covers activities in various divisions, however, the chairman becomes a member of the committee. The present committee personnel are:

W. R. LaDue, *Chairman*

L. S. Finch, *Vice Chairman*	H. E. Hudson Jr.
	J. M. Jester
L. E. Ayres	A. P. Kuranz
J. J. Barr	R. J. McLeod
E. L. Bean	R. S. Millar
E. S. Cole	J. H. Murdoch Jr.
John G. Copley	L. N. Thompson
G. H. Dyer	A. A. Ulrich
M. P. Hatcher	W. V. Weir

R. J. Faust, *Ex Officio*

Inactive Subcommittees

The following subcommittees are now inactive or have not been activated:

4110M—Constitutional and Statutory Aspects of Municipal Water Works Organization

4150M—Taxation and Revenue Allocation (task group active)

4210M—Public Relations (An ad hoc committee of the Board is currently studying the subject of public information.)

4220M—Management Relations

4310M—Construction Equipment and Material Contracts

4320M—Valuation and Depreciation

4330M—Cost Trends

4410M—Water Department Reports (advisor retained)

4441—Industrial Water

1957 Conference

At the 1957 Conference, numerous principal topics stemming from the committees' activities, either directly or indirectly, were presented at the various sessions. Attendance was good and member interest was unusually high. In fact, the open session of the Committee on Water Works Administration attracted one of the highest attendances of the Conference.

Subcommittee Activities

The continuing and growing importance of the diversified phases of water

works management and administration is evidenced by the steady flow of inquiries into AWWA headquarters and to several committees regarding committee activities. These inquiries indicate a need for studied, increased, and continuing activity in all phases of the committee's present field of endeavor and expansion into other fields, as the Association's program, personnel, and budget will permit, and as the membership requires. The problems of administration are increasing in complexity.

Following is a brief summary of the activities of the several subcommittees during the year 1957 as submitted by the committee chairmen:

4120M—Radio and Mobile Communication Facilities for Water Works. The committee's activity this year has been in support of work handled through Secretary Jordan's office. It is planned to discuss the desirability of making a survey of the water utilities which are users or potential users of short-wave radio equipment, in order that a survey made in August, 1955, can be brought up to date. Figures on populations served by these utilities are of extreme value to the national committee in connection with its work, especially that involving available frequency allotments and changes by the Federal Communications Commission. It is also becoming more and more important that the members of the Association should be advised of the importance of their facilities in connection with the performance of these operations in an efficient manner, rendering to the public the service which it not only demands, but deserves as well. The use of microwave equipment in connection with efficient operation is coming into the picture to replace land line facilities, which are subject to failure, especially during periods of disaster or stormy weather, when such facilities are most likely to be needed.

4121J—National Committee for Utilities Radio. The work of this committee continues primarily in connection with Docket 11866 pending before the FCC, involving the allocations of frequencies in the power utilities group to certain communications groups. A brief was prepared and submitted by Chairman John M. Jester to the legal representatives of the National Committee for Utilities Radio. The brief was submitted to the FCC, along with those of other groups, opposing the allocation of frequencies assigned to the power utilities group.

During 1955 a rather comprehensive survey of the use of mobile radio facilities for water utilities by the Association showed that 429 utilities were using mobile radio equipment, and there were at the time 467 potential users, serving an estimated population in excess of 11,500,000, yet to file for licenses.

It is during the night hours, as well as periods of storm or disaster, that the normal land facilities available generally fail and reliable communications are most urgently needed by the water utility for close contact between its major control centers and operating forces.

4130M—Water Used in Air Conditioning and Other Refrigeration. This committee has been actively engaged in studying the continuing problems. The industry is expanding so explosively that it now affects, or will soon materially affect, practically every water utility in the country, in such approaches as expanding costs, rate structures, water conservation, regulatory methods, tariffs, and legal phases.

A survey of all ordinances, regulations, or special charges affecting use

of water in air conditioning or other refrigeration is in progress. Questionnaires were distributed to all members in the United States, Canada, Cuba, and Hawaii in April 1957. Based on replies to May 10th, a preliminary report was presented at the 1957 Conference in Atlantic City.

Replies were eventually received from nearly 700 members, some 450 of these reporting entirely in the negative. All affirmative replies and suggestions were checked by personal correspondence and supplementary information obtained. Officially confirmed information shows that 203 communities in United States and Canada have regulations, special charges, or both. From approximately 80 per cent of these, copies of the ordinances or regulations were obtained, and information tabulated therefrom. [This report was published in the January 1958 JOURNAL.]

4140M—Water Use in Fire Prevention and Protection. This committee is at present functioning on a standby basis to observe the effects of the National Board of Fire Underwriters' revised rules and regulations. A report was made at Atlantic City upon a comparison of the new with the old NBFU regulations. The committee urges that members of AWWA review their own situations in light of the changes.

4150M—Taxation and Revenue Allocation. Although this committee is not yet active, AWWA has had occasion to present to governmental agencies the water utility viewpoint on the important subject of payment of charges due to relocation of facilities proposed by highway authorities. This problem remains constantly before utility managers, while an accelerated program of superhighways and turnpikes develops and continues to expand, encouraged by current federal highway legislation and its recommended implementation.

Evidence is present in some areas that aid has been given by direct monetary means, by inclusion in the contract of a portion of the changes to be made, or by furnishing of both labor and material as part of the highway construction contract. Although evidence apparently favors state control, each water utility should maintain constant vigilance of local, state, and national developments.

4210M—Public Relations. By Board action this committee has been dissolved and its work is now in the hands of an ad hoc committee (1140) reporting to the Board. An intensive study of the approach to the problem is under way, with John H. Murdoch Jr. as advisor and consultant. The Association greatly desires to aid its membership in its quest to attain and hold consumer attention and respect. [A report of this committee appears in this (April 1958) JOURNAL, p. 453.]

4230M—Compensation of Water Works Personnel. Since AWWA headquarters evaluated the *Survey of Employment Conditions* in 1954, the work of this committee has been negligible. It is now being activated. The committee has been studying the problem of proper compensation for water utility personnel, especially as it pertains to the manager of the utility property, with the idea that if compensation for the top man is sufficient, he will see to it that the compensation of those under him is also in line. Considerable study has been given to the proper method of obtaining basic information, and it has been decided to send a questionnaire to a group of water managers in order to ascertain the present situation as to salaries and

their relationship to other factors. A great deal of work has been done in setting up a proper questionnaire, and at the present time this information is being correlated and a questionnaire formulated. Also, considerable information is being assembled concerning compensation to comparable executives in other utilities. The basic questionnaire should be in form in the near future so that it may be mailed out and the information tabulated.

A survey should be made of both municipal and private water utility fringe benefit policies. These items become important in negotiations, because they do have some bearing on the size of the wage demand, and the fringe benefits have become rather expensive.

Task Group 2210M (formed to study job classifications) is working under the jurisdiction of the Water Works Management Division.

4240M—Pension and Retirement Plans. Pressure to place state pension systems under the federal Social Security act continues. Changing national attitudes towards all types of pension systems will affect the water works field and will bear constant attention by this group.

The questionnaire form, approved by the committee at the 1957 Conference, has been mailed to all water supply organizations serving populations of 30,000 and more. The return has been excellent, and the preliminary analysis of these questionnaires is under way. Specific pension plans will be sent to the members of the committee for more detailed study and analysis. It is hoped that a final report can be presented at the 1958 Conference.

4250M—Safety Practices. The main activity of the four task groups of this committee was the successful preparation of the AWWA manual, *Safety Practice for Water Utilities,* which was printed serially in the JOURNAL (July–December 1955). It has been subsequently printed under its own cover and is now available from the AWWA office at a nominal cost.

On Jan. 28, 1957, the Board of Directors of AWWA at its annual winter meeting considered and unanimously approved a safety award plan for water utilities. This action of the Board achieved an objective of the Safety Practices Committee that had been under consideration for almost 2 years. As Wendell R. LaDue has been, in effect, the AWWA member responsible for the initiation of the safety plan as a whole, the Board agreed that the three general AWWA awards should be titled the Wendell R. LaDue Awards. Certificates have been prepared.

The award plan was developed with the purpose of stimulating water utilities to start safety programs where none existed and keep already organized and operating safety programs at a high degree of efficiency. The safety award plan is divided into two parts. One relates to the sections and the second to the parent Association. Awards at the section level will be given on an annual basis to all utilities that earn them. AWWA awards will also be given annually, but the number will be limited to three.

Safety is a personal matter—a way of life—which needs occasional encouragement to keep its objectives foremost in people's thinking. The award plan was designed to help accomplish that awareness of safety which is so necessary to any successful program.

In the fall of 1957, five sections—Kentucky-Tennessee, Southwest, New Jersey, California, and Virginia—pre-

sented a total of 81 safety award certificates. These included seven Awards of Honor, 68 Awards of Merit and 6 Awards of Progress. This represents a good start, but the program should be in full force during 1958, because the 1956 and 1957 safety results will be available for comparison.

The report forms for the year 1957 were mailed to all sections late in December to permit those with winter and spring meetings to be prepared for them. Records show that eighteen of the 30 sections have safety committees. Although records may not be complete, it appears that the following sections are without a safety committee: Alabama-Mississippi, Canadian, Chesapeake, Cuban, Montana, North Carolina, Ohio, Pacific Northwest, Pennsylvania, Rocky Mountain, Southeastern, and West Virginia.

The AWWA Safety Practices Committee also thought that it might be appropriate to have the Board designate a Water Utility Safety Month to add interest in the program. During the Safety Month, the JOURNAL and *Willing Water* would feature articles on safety. Cities could participate, and the manufacturers who advertise in the JOURNAL might feature the safety features built into their equipment. The total effort would be to highlight safety.

4260M—Education. At the 1957 Conference, the Board of Directors approved the recommendation of the committee to reduce the number of inservice training manuals in preparation from six to four, to avoid duplication of material. The four manuals in preparation are: [1] Development of Water Supply, [2] Treatment of Water, [3] Distribution of Water, and [4] Water Works Management. The writing of the manuals, as was expected, developed some difficulties. First, the idea of employing a single writer for each manual was found to be impractical. Generally, people could not be found to do the writing at the price AWWA was willing to pay. The committee found that few people feel qualified to write an entire manual.

Practically all of the text writing is completed for the four manuals. Manuals 1 and 2 are being put together from the material originally prepared for four manuals, but will probably not be ready for publication in 1958. Manual 3 is written and now is being reviewed for technical competence. Manual 4 is now in process of editing. Much editorial work is required to make each manual a finished work. One and possibly two manuals should, however, appear in 1958, the other two in 1959.

When the committee is largely through with its work on the manuals, it may consider educational qualifications for water utility executives.

This committee is commended upon its excellent approach and outstanding enthusiasm.

4340M—Water Main Extension Policy. This committee has been continuously active. With the population trend producing suburban development, public service commission policies toward main extensions will bear close watching, as will the effect of the trend back towards urban redevelopment.

This committee is just beginning the task of reevaluating its position after the change in its chairmanship. The committee has worked about 9 years under the capable leadership of Lewis S. Finch, who decided to withdraw from the committee because of the pressure of his other work with the Association.

The committee needs now to look back on what has been done and then to chart its course for the future. It appears from past work that the fundamentals of the whole water main extension policy—urban and suburban—have been fairly well delineated. The need now is for enough surveys of practices to show the trend of thinking, and for reviews of material prepared by others—by the public service commissions, for example. The entire subject is of direct, pertinent, member concern.

4420M—Water Rates. The committee is presently at standby basis, although review and revision of water rates under changing economic conditions are necessary parts of the proper administration of a healthy water utility. The widespread use of air conditioning poses a problem in rates. The control of the funds, provided by rates, is also a matter for constant surveillance, so that the water utility may receive and use its own funds necessary for successful operation and expansion.

The subject is perennial by nature, and new trends will be studied as they may develop.

4430M—Joint Administration of Water and Sewer Facilities. With the general acceptance of the sewerage service charge and its almost universal collection by the water utility office, the trend toward joint administration is expanding with attendant problems.

A state-by-state study on the authority granted water utilities to levy assessments for installation of water mains and sewers against abutting property should produce valuable and interesting information to the membership. The biggest problem would be where to secure the information. A study should be undertaken to determine a practice under which recovery is made for the installation of water mains and sewers, both within and outside of the corporate limits of the municipality. There is a rather widespread and variable practice in this respect.

Results of the current questionnaire are being prepared for publication. Although a preliminary report was given for the committee at the 1957 Conference, there was accumulated much material that was felt could best be presented in tabular form for publication early in 1958.

4440M—Water Use. The committee continues its studies of the effects of geography and the kinds of water needed to fill industrial requirements and will outline the various schemes for industrial water conservation. It is studying the various trends and demands of domestic (residential) uses, with particular stress upon the causes of per capita increase and seasonal and hourly variations. The many divergent uses of water will, in time, produce areas of conflict, requiring careful analysis of the possible priority of use of some supplies. Regulations against waste are forthcoming.

A review is in progress of data on water use in 120 cities, and a questionnaire is in preparation to circulate to a small number of cities to obtain detailed information on peak demands, especially residential use. The former is approaching completion. Data are being sorted by climatic regions to determine effect of climate on general average residential use. It is expected that some data will be available from cities in major categories to report at the 1958 Conference.

The committee will have a technical report to present at the 1958 Conference at Dallas. This will be a progress report, of a pilot nature, test-

ing the plans now prepared and in preparation for a large-scale collection of data during 1958–59.

4450D—Revenue-Producing Water. This committee has been expanded and an attempt is being made to arrive at a more descriptive name. The committee works in the field of interest of the Water Distribution Division, which is giving valuable assistance and impetus.

The committee's extensive and valuable report was published in the December 1957 JOURNAL. It is hoped that there will be some extensive discussion to consider. The committee will remain in active status as long as desired.

Research and Development Groups

2210M—Job Classifications. This is a task group in the province of the Management Division. It will be helpful to Committee 4230M (Compensation of Water Works Personnel). Considerable progress in outlining the work of this committee is being made.

The Colorado State Employment Security Office, affiliated with the US Department of Labor, has almost completed full aptitude-test batteries to determine norms for filter plant trainees. The catalog of tests and test materials includes under occupational listings many water utilities jobs for office and engineering groups, some for mechanics, machine operators, and so forth, but none for the water treatment group. Upon completion of the filter plant trainee aptitude-test batteries, effort will be made to have the field of distribution system labor investigated. This is the type of endeavor encouraging to the committee.

2220M—Review and Redevelopment of a Rating Scale for Water Works. The chairman of the group and its members have spoken before sections of the Association and before other interested water utility groups upon the value of the work of this group. It is believed that several years will be required before anyone can say that the work is approaching completion. So far, it has been determined that the group will concern itself with the following general phases: [1] financing, rate structure, and metering (2221M), [2] accounting, collecting, and recording (2222M), [3] organization, management, and training (2223M), [4] supply, transmission, and pressure (2224M), [5] purification and treatment (2225M), and [6] distribution (2226M).

The task group and its associated groups are now organized to study each phase. Associated groups are being urged to push work in their assigned fields. Good progress is being made by Group 2224M and its pattern may be a guide to other groups. The chairman hopes to visit the regions in which some of the associated groups are located in order to have an opportunity to discuss their work in detail. In addition, he has asked for time at the 1958 Conference for his task group to get together.

2230M—Committee to Cooperate With NARUC Committee on Revision of System of Accounts for Water Utilities. This committee worked earnestly and very hard for more than 4 years in an attempt to bring the system of accounts promulgated by NARUC into realistic relationship to the construction and operating practices of water utilities. Although these rules are mandatory only upon the operators of privately owned utilities, the classification of accounts is extensively used

in publicly owned systems. At the annual convention of NARUC held in Memphis, Tenn., in October 1957, the following resolution was adopted regarding the uniform system of accounts for water utilities:

Whereas, the committee on accounts and statistics of this association, after extended study and many conferences, recommends certain changes in the uniform system of accounts for water utilities heretofore adopted by this association, as set forth in a draft dated Apr. 1, 1957, of a revised uniform system of accounts for water utilities, which has been presented by said committee to the association; and

Whereas, this association believes that uniformity in utility accounting is most desirable in the public interest;

Resolved that the revised uniform system of accounts for water utilities submitted by said committee be recommended to the commissions represented in the membership of this association for consideration, and for adoption in their respective jurisdictions, with such modifications only as they may deem necessary in the public interest.

There remains, of course, the need for adoption of the new system by the various regulatory commissions who have jurisdiction over the operations of water utilities. It is, however, the opinion that any action in this direction should be accomplished by either the interested utilities themselves or possibly by some uniform front on the part of the various sections of AWWA. It has frequently been suggested that a continuing accounting committee should be established within the framework of AWWA.

A currently active problem is in the system of accounting for funds used in cleaning, lining, and rehabilitation of old mains. Encouraging avenues of agreement present themselves from time to time, so that in the end many favorable changes in procedure may result. The committee's approach to the handling of this problem has been excellent.

2240M—Committee to Cooperate With NARUC Committee on Proposed Rules and Regulations Governing Water Service. The committee has been attempting to cooperate with the NARUC Engineering Committee on proposed standard rules and regulations governing water utilities. Several conferences have been held. The AWWA Committee has not, however, gone along with ideas which it cannot approve. Work is completed so far as the NARUC committee is concerned. Its report has been filed. This committee should be kept informed of state commission action or plans for action on NARUC rules. If so informed it might be able to give service to water works in the state in question.

Recommendations

The attention of the Board is again directed to the necessary enlarging of the activities of the Committee on Water Works Administration along several lines, as hereinbefore noted. There are numerous projects of the committee which cannot be handled efficiently on a member-committee basis. They involve a large amount of research and could best be handled as staff projects. The Association's budget might be supplemented by outside funds, especially when a project involves items in which manufacturers or industries are vitally concerned. The subcommittee activities which might be considered as projects requiring staff aid are:

4110M—Constitutional and Statutory Aspects of Municipal Water Works Organization

4150M—Taxation and Revenue Allocation

4210M—Public Relations (now Ad Hoc Committee 1140)

4230M—Compensation of Water Works Employees.

It is the aim of the Committee on Water Works Administration to proceed deliberately, acting upon and anticipating obvious member demands and expanding interests; to establish a long-time policy of continuing activities; to maintain close cooperation with the Committee on Water Works Practice; and to encourage obvious member participation as task groups of the various divisions. Appreciation is hereby extended to AWWA personnel and to all committee chairmen and members for the many services rendered. The ever-valued counsel, consideration, and guidance of the members of the Board of Directors are gratefully acknowledged.

Survey on Well Stimulation

An investigation is now being conducted to determine whether the techniques of water well stimulation, such as acidizing, treatment with other chemicals, shooting, and hydraulic fracturing, now used to a limited extent, might not be more generally applicable nationwide for the benefit of the water works field. Used in the oil production industry for many years, these techniques seem applicable to the development of ground water supplies. To determine the extent to which these methods have been used by water utilities, case histories are being collected in a comprehensive study by Louis Koenig, consulting engineer, San Antonio, Tex.

To date, 350 case histories, scattered over the country from California to Pennsylvania and from Texas to Wisconsin, have revealed that only 6 per cent of the jobs are failures and that 50 per cent result in flow increases of more than 300 per cent. In one-third of the cases reported, flows have been increased by more than 1,000 per cent. Improvements of this magnitude are achieved even in formations of initially very high permeability.

Information is now being sought on specific individual uses of water well stimulation—those which resulted in failures as well as those which have been successful. Well owners, engineers, drillers, and others are asked to contribute data to this survey. Those willing to cooperate should drop a postcard to Louis Koenig, 6702 Blanco Road, San Antonio 12, Tex. A special checklist form will be supplied for reporting the data.

To help make this first comprehensive study of this potentially important resource development technique a success, all who have information are urged to send it along. The results and conclusions will be published for the benefit of the industry.

Report of the Committee on Water Works Practice

For the Year Ending December 31, 1957

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1957, submitted to the AWWA Board of Directors on Jan. 26, 1958, by Louis R. Howson, Chairman.

THE Association's activity in the field of standardization has continued constructively during the year 1957. Incidental to the consideration given during the year to the proposed certification program, it has been established, at the advice of the Association's attorney, that the standardization documents of this Association hereafter will be entitled "Standards" instead of "Specifications." The term "Specifications" will hereafter be used in referring to contract documents.

Several standards, which have been in the hands of subcommittees, have been completed and will be offered for consideration during the discussion of this report. They cover: deep wells, wet barrel hydrants, gate valves, liquid alum, and backflow preventers.

The following documents, previously approved by the Board as Tentative, are recommended for advancement to Standard status:

B404—Standard for Liquid Sodium Silicate

C301—Standard for Reinforced Concrete Water Pipe, Steel Cylinder Type, Prestressed

C504—Butterfly Valves—Rubber Seated (as of Jun. 1, 1958)

C505—Butterfly Valves—Metal Seated (as of Jun. 1, 1958).

No suggestions are on file for further changes in the documents. [Upon notice, the Board approved advancement of these documents to Standard status.]

The following documents have been current as tentative standards for the period indicated in the title of each item listed below. In the opinion of the chairman, each one should be given further consideration by committees especially appointed for the purpose and then considered for Standard status:

C400—Tentative Standard for Asbestos-Cement Water Pipe (Approved as Tentative, May 1953)

C501—Tentative Standard for Sluice Gates (Approved as Tentative, June 1941)

C600—Tentative Standard for Installation of Cast-Iron Water Mains Approved as Tentative, June 1949; revised, May 1954).

[The appointment of special task groups to consider the necessary changes in the above documents was deferred.]

Fluoride standards. The newly formed advisory committee for review of chemical standards (7311 P), with Oscar Gullans as chairman, has started with the fluoride standards. These standards were subjected to criticism on two counts: feasibility of feeding the material and the limitations on eight impurities.

After preliminary study of the complaints, the committee reported its findings at the 1957 Annual Conference. On the basis of that report and with additional information, revised copies of B701 (Sodium Fluoride), B702 (Sodium Silicofluoride), and B703 (Fluosilicic Acid) were prepared and, on Oct. 30, sent to a selected group of manufacturers and users for their review and comment. The returned comment was ample, pointed, and related mainly to feeding. It was so voluminous that it became necessary for the committee to miss the previously arranged deadline of Dec. 6 for completing the standards. More time for study of the problems involved is needed.

The chief problem is how to devise a standard which will assure good feedability of the fluorides. Several factors are involved, such as size and moisture content. Storage qualities are also involved. Brantford, Ont., and Winnipeg, Man., have experienced difficulty with sodium silicofluoride of foreign manufacture (Netherlands) which tends to harden into a solid after about 20 days of storage under the weight of two or more bags. This condition is being examined by means of sample analysis of the offending material.

It is not at all certain that the difficulties with solidification in storage can be eliminated by terms of a standard. It may be necessary to point out to the purchasers of sodium silicofluoride that the material tends to solidify in bag storage, and this solidification can be overcome by the use of a farmer's feed grinder before the material is placed in the regular proportioning feeder. An operation of this character, however, requires that consideration be given by the producer or purchaser to a reduction in price sufficient to compensate for the cost of grinding the material before use. The changes in the standards should be completed and made ready for Board action at the 1958 Conference in Dallas.

Liquid chlorine. The Tentative Standard for Liquid Chlorine has been accepted by the Water Works Practice Committee and the Board of Directors. [This document was published as AWWA B301-57T in the February 1958 JOURNAL.]

A research project on the impurities in liquid chlorine has been given a grant-in-aid by the National Institutes of Health and the work has been initiated by Professor Mellon of Purdue University. The committee on standards for liquid chlorine found itself unable to express specifically the limits upon certain impurities (such as nitrogen trichloride), because analytical procedures for determining these materials were not sufficiently stabilized to justify their inclusion in a standard.

Copper sulfate. This standard, which has been under development for several years, has been approved by the Water Works Practice Committee and the Board of Directors [published in the January 1958 JOURNAL].

Joint Committee on Oil Line River Crossings. This important project during the past year has not involved meetings between representatives of the water works industry and the petroleum industry, but the following recommendations are made by M. B. Cunningham, chairman of the joint committee:

1. During the past year there has been made an additional suggestion. If the pipeline crossing is above the intake of the water system, under certain conditions, the installation of a detection system would be desirable for instant identi-

fication of a pipeline break. This would be accomplished by the installation of a flow indicator on the line where the flow enters the drainage area, and a flow indicator where the flow within the pipeline would be leaving the drainage area above the water intake. These flow indicators could be set up to transmit by remote control, either by wire or by radio, and the receiving instrument could show parallel lines as long as there is no change in the flow characteristics of the pipe. The pipeline break would immediately distort the two instruments and set up an alarm system which could be one of a good many available.

2. In checking pipeline permits, we find a wide variation from one state to another. It has been determined that under the usual procedure where pipelines extend through the corporate limits of a city, permits are issued by the city. Many county governments require permits for crossing public roads. There is generally a state agency which has control over the oil industry, and this state agency issues a permit. We also find, that on streams classified as navigable streams, the pipeline permits are usually issued by the district engineer, Corps of Engineers, US Army.

3. There are many desirable design features to be considered, especially when plans and specifications for the construction are being prepared. Where such lines cross above the water department intake, safety factors to be included in the design should be checked by the water department involved with the appropriate oil company, or by notice to the appropriate agency issuing the permit to cross the stream.

It would be to the advantage of the water department having an intake on a stream in an area where oil lines are likely to be constructed above their intake, to give notice of the possible damage which would occur by breaking of the pipeline, and such notice could be given to the various governmental agencies within the state, or interstate, which would have anything to do with the issuance of a permit or license for the pipeline crossing. Valves should be located in every pipeline on both sides of the river or lake, and these valves should be in accessible places, such as near a state highway or an all-weather road. The water department or company in question, together with the oil companies, should be familiar with the setup and have access keys, facilities, and so forth, for prompt closing of the valves in the event of a break or excessive leakage. Such action on the part of the water utility should only be on request of the pipeline authorities, for they may not have anyone on duty within many miles of the break.

4. Each stream crossing would have its own design problems, in which the crossing might be either underground or overhead. An overhead crossing is desirable wherever it is practical.

Stream crossings have their own individual soil conditions, which must be taken into consideration. Also, there is a wide variation in the flow characteristics of rivers, as to whether scouring or deposits will occur—or bank cave-ins—and many other details will determine the design and safety factors necessary to be incorporated in the construction of a safe pipeline crossing. The committee would be glad to have any comment or suggestions as to further work desired.

The circumstances reported by Chairman Cunningham are of a nature which is beyond the scope of ordinary standardization activity on the part of this Association. It will be necessary not only to develop a consensus between the representatives of the petroleum industry and the representatives of AWWA, but also to develop an accord with the Army Engineer Corps representatives who have a responsibility in this matter and the various state agencies which issue regulations of oil line installations. [Initiation of further action in this matter was deferred until the 1958 Conference.]

Pipe design allowances for water hammer. The work of this task group, under the chairmanship of S. Logan Kerr, was reported formally at the 1957 Conference in Atlantic City. The committee considers its work is complete and has requested that it be discharged. A discussion which developed between the chairman of the committee and one of the members of the Water Works Practice Committee delayed publication of the task group report. [The report appeared in the March 1958 JOURNAL. The Board thanked the task group for its excellent work, and it was discharged from further responsibility in the matter.]

Joint Committee on Spillway Design. This activity, which is a joint one involving authorization both by AWWA and ASCE, was set up only after a special study committee of the two organizations had recommended that formal joint committee activity be established. After the joint committee had been established under the chairmanship of Thomas H. Wiggin, with appointments made both from AWWA and ASCE, the hydraulic division of ASCE initiated a similar project. The division committee proposed to carry on work which is the practical equivalent of the work which has been authorized for action by the joint committee.

At the January 1957 meeting of the Board, authority was given to Chairman Wiggin to withdraw his committee from operation under the joint auspices and continue the work which he had planned under the sole sponsorship of AWWA. Chairman Wiggin has been very patient in following this authorization. [On Jan. 17, 1958, the chairman had a conference with the chairman of the ASCE hydraulic division committee, Harvey O. Banks. At that time, they reached the conclusion that the functions and activities of the two committees could not be separated by action upon the part of the Chairmen. Therefore, they agreed to report to AWWA and ASCE recommending that the spillway design projects be amalgamated and reorganized. [The AWWA Board approved the recommendation.]

Joint Committee on Backflow Preventers. This committee has completed its work. Prepublication has made the document available to the members of the Committee on Water Works Practice, as well as to the members of the AWWA Board of Directors. It is recommended that the Progress Report be approved for publication in the JOURNAL, with the provision that the material be considered only an outline of policy in principle acceptable to the officers and directors of AWWA and, further, only when approved by the officers of the Conference of State Sanitary Engineers. It is further recommended that the document be considered "Tentative" for at least 1 year after publication and the joint committee be held responsible for clarification of questions and issues raised by those who study the document after its publication. The reason for this suggestion is the fact that much of the material in the document impinges upon state and local regulations or ordinances, and may in part run contrary to existing controls and procedures which have been found satisfactory within the area where they are released by official action. [The Board approved the recommendation that the report be published when it had been approved by the Conference of State Sanitary Engineers, with the understanding that publication is intended to be informative so far as

AWWA members are concerned, but not a complete endorsement or acceptance of the detailed terms of the report.]

Cast-iron pipe. The ASA A21 Committee on Standards for Cast Iron Pipe continues its work under the chairmanship of Thomas H. Wiggin. During the year the second edition of the American Standard Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe (ASA A21.1; AWWA C101) has been completed and published. This is a much more complete and useful document than was the first (1939) edition.

The ASA A21 Committee, under which cast-iron pipe standards are developed, has been reorganized. The number of representatives on the committee has been reduced. [The committee as reorganized held its first meeting at AWWA headquarters on Jan. 29, 1958. Thomas H. Wiggin was chosen to act as chairman of the committee, and Raymond J. Faust, as secretary.]

Cement-mortar linings. Thomas H. Wiggin has renewed his suggestion that a special task group be established to make a critical examination of the cement used for mortar linings for cast-iron pipe and steel pipe. The Association has two standard documents upon this subject—C104, Standard for Cement-Mortar Lining for Cast-Iron Pipe and Fittings, and C205, Standard for Cement-Mortar Protective Coatings for Steel Water Pipe of Sizes 30 Inches and Over. Wiggin strongly holds the opinion that a more explicit requirement should be set up to cover the type and quality of cement to be used for this purpose. A project of this character will require the complete cooperation of the Portland Cement Association if the study is to be at all useful. Whether this should be a project of AWWA alone, or jointly with ASTM, or perhaps under ASA procedure, remains to be decided. [No action was taken by the Board on this matter.]

Steel pipe. Editorial changes in the Manual for the Design and Installation of Steel Water Pipe have been completed. Standard AWWA C203—Coal-Tar Enamel Protective Coatings for Steel Pipe—is being revised to include field peel test, water absorption test, and many changes to material and installation requirements. Standard AWWA C205—Cement-Mortar Protective Coatings for Steel Pipe—is in process of being revised. A plastic coating subcommittee has been formed to study new materials and methods of protection for steel pipe. Investigations are being conducted on the possibility of using steel plate of high tensile strength, together with new steel pipe joints. The steel pipe committee has been aided by the Steel Water Pipe Manufacturers Technical Advisory Committee in all of its activities.

Reinforced concrete pipe. The present tentative document, Standard for Reinforced Concrete Water Pipe—Steel Cylinder Type, Prestressed (C301), is recommended for advancement to Standard status. Revisions of C300 and C302 were approved and published during 1957. The committee is developing a manual on the installation of reinforced concrete water pipe, which is not yet ready for submittal, either to the Water Works Practice Committee or the Board of Directors. [The Board approved advancement of C301 to Standard status.]

Asbestos-cement pipe. It is recommended that the Association's present tentative standard (C400), published

in the July 1953 JOURNAL, be placed in the hands of a special task group and made more precise in some of its terms. This is desirable in view of the fact that asbestos-cement pipe manufactured outside North America is being offered in the American market. This material is less satisfactory for water works installations than that produced in this country in accordance with the AWWA standard. Certain indefiniteness in the AWWA standard makes it possible for this material to be accepted for use in water utility installations in the United States, when in fact it does not conform to the AWWA standard, although it may be represented as such. [The Board approved.]

Reinforced concrete water storage reservoirs. It has been suggested that a committee be authorized for action under the jurisdiction of the Water Works Practice Committee to develop a manual of recommended design of reinforced concrete water storage reservoirs. Such a document may be developed to cover both prestressed and nonprestressed reinforced concrete reservoirs jointly, or two documents may be developed separately. The British Standards Assn. has in circulation a tentative document covering both. The British document may be used as a basis of reference by a committee which would be established by AWWA. In the opinion of the chairman of the Water Works Practice Committee, there are too many variables related to the design of a reinforced concrete reservoir to make standardization desirable. [Lacking an affirmative recommendation by the chairman, the Board took no action on this matter.]

Deep wells. A revised text of the deep well standard (A100) is recommended for Board action, for approval as a document jointly sponsored by AWWA and the National Water Well Assn., with publication to continue as an AWWA responsibility. [The Board approved the revisions in this standard, as well as its future designation as a joint document of AWWA and the National Water Well Assn. California Section Director Harnish pointed out, however, that the present standard, as well as the revised document, lacks reference to the thin-wall casing type of well, commonly called the "stovepipe-type" well. Harnish was advised to file a written memorandum with the Secretary outlining the material which the California Section members believe is needed to make the document satisfactory for reference in that area.]

Valves. The 1952 Standard for Gate Valves for Ordinary Water Works Service (C500) has been revised under the direction of a committee, with David Auld as chairman A report of that committee (plus certain material which was not completed by the committee, but which has been embodied in the document by the Secretary) is offered for consideration by the Board with the approval of the Water Works Practice Committee. [The Secretary pointed out that a number of objections had been raised to the proposed revision of the gate valve standard. Therefore, it was recommended that no action be taken by the Board at this time, other than to affirm its desire to have a revision of this standard developed promptly in a form acceptable to the Board.]

Sluice gates. The present tentative document (C501), published in 1941, needs consideration by a reactivated group. A very fine critique of the present document has been filed by Kenneth Wilkes of Sacramento, Calif.

His comments will be made available to any committee authorized to revise the current tentative standard. [The Board voted to submit the document to a committee for further consideration.]

Fire hydrants. With the very fine cooperation of a committee composed of users and manufacturers of wet-barrel fire hydrants, a document covering this type of equipment has been prepared, submitted in final form to the Water Works Practice Committee and to the California working committee. It has been approved by both groups, and is recommended for approval by the Board of Directors. This proposed standard covers a category which has not been previously included in any document issued by AWWA. It will meet a need of those members whose activities are carried on in areas where freezing weather does not occur during the winter months. [The standard was approved by the Board for publication.]

Butterfly valves. AWWA has approved two documents under this category—Rubber-Seated Butterfly Valves (C504) and Metal-Seated Butterfly Valves (C505). Both of these documents were modified in part by the committee in May 1957. Their advancement to Standard status as of Jun. 1, 1958, is recommended. [The Board approved.]

Meters. The committee which has in its charge the revision of standards for water meters has no activity current relating to revision of the displacement type, current type, compound type, fire service type, or current type, propeller driven. The committee has completed the Tentative AWWA Standard for Testing Cold-Water Meters. This was published for general circulation in the June 1956 issue of *Willing Water* and is now available in booklet form as AWWA C705. The document is being held in tentative status, subject to criticism and comment. If no substantial objections are made to the document, it will be submitted to the Board for approval as standard during the 1958 Annual Conference and published in the JOURNAL later in the year. The committee has in preparation a meter manual, which is intended to be a general outline of recommended procedure for the installation, reading, servicing, testing, and other details of control of water meters. The document gives promise of having great value—since meters, as is often stated, are the cash registers of the water works business.

Joint Committee on Steel Standpipes and Elevated Tanks. This is a joint operation with the American Welding Society, and now operates under the direction of J. O. Jackson as chairman, following the retirement from active business of the former chairman, H. O. Hill. The committee expects to have available for consideration shortly a revision of the text of the standard insofar as it relates to structural details.

At midyear 1957, the question arose concerning the toxicity of lead pigment as used in water tank paint. One meeting to consider the situation has been held in Pittsburgh and one in Cincinnati. Representatives of the US Public Health Service, the Lead Industries Assn., the Steel Structures Painting Council, and AWWA were present at these meetings. There is current among the individuals who are primarily concerned with toxic elements in the environment a considerable concern over the possibility of cumulative lead poisoning—from the atmosphere, from foods, and from water. In the conference which was held in Cincinnati in mid-December, it was

pointed out by Dr. Kehoe, of the Kettering Institute, that the average individual in the US is obtaining about 3 mg of lead per day in his food, and any unnecessary addition to this lead intake is undesirable. Chairman Jackson of the joint committee and the Secretary are seriously concerned over this matter, since red lead has been from time immemorial a very useful compoonent in paints for water tank metal protection. A study is projected which will involve periodical examination of water taken from tanks painted during the year 1958 (in which lead is a component of the internal coating of the tank) to ascertain just exactly how much and how long lead appears in water taken from the tank. At the present time, there is no firm basis upon which a decision can be made concerning the nonuse of lead-base paints in interior painting of water tanks. It is necessary to have such information before a final decision concerning the details of the text of the next recommended procedure for painting elevated tanks can be completed.

Plastics. AWWA continues to participate in the activities of two committees relating to the production of plastic pipe and fittings through its representative, Raymond J. Faust. These committees are: [1] a subcommittee of the ASME Committee B16—Pipe Flanges and Fittings; and [2] the ASTM Committee on Plastic Pipe. Although progress is being made by both committees, neither one has brought its work to the point where formal consideration needs to be given by AWWA to the acceptance of plastic pipe tubing or fittings as service line materials.

The Department of Commerce has issued two commercial standard documents as follows: CS197–57—"Flexible Polyethylene Plastic Pipe," and CS207-57—"Dimensions and Tolerances for Rigid Polyvinyl Chloride Pipe."

At a meeting of the Board in January 1957 it was approved that AWWA appoint a committee, under Water Works Practice Committee jurisdiction, to evaluate plastic pipe, tubing, or fittings whenever it appeared possible that such materials could be officially included in the AWWA list of standards. Since that time has not come, no working committee has been appointed.

Manual of Water Quality and Treatment. Revisions of three chapters of the manual were published as follows: aeration, August 1955; mixing, flocculation, and settling, September 1955; and filtration, July 1956. Reprints of these revised chapters are being sent to all persons who now purchase a copy of the manual as published in 1951.

The Water Purification Division should be requested to consider whether the time has come to establish a working committee to prepare a complete revision of the *Manual of Water Quality and Treatment.*

ASCE-AWWA Manual on Filtration of Water. This is a manual of design in process of development by a joint committee headed by Ray L. Derby of the Los Angeles Department of Water and Power. Sections of this manual have been assigned to several persons. Some portions of the material are in completed form, and some portions are as yet only in preliminary form. No date for the issuance of the manual has been set.

Standard Methods for the Examination of Water, Sewage and Industrial Wastes. The Joint Editorial Committee for the 11th edition of *Standard*

Methods has set the deadline of 1960, as the date of issuance of the next edition. Michael Taras of the Detroit Water Department continues to represent AWWA on the Joint Editorial Committee with diligence and with intelligence. A number of groups of revision subcommittees operating under his general direction are listed in the 1957 Reference Edition of the AWWA Directory. Several sets of texts of revised procedures have been prepared by the subcommittees and are under consideration by those concerned with the next edition of *Standard Methods*.

In the January 1958 JOURNAL, there appeared a statement announcing the acceptance of the membrane filter procedure for bacteriological examination of water as an alternate to the standard MPN procedure, which appeared in the 10th edition of *Standard Methods*. Circumstances relating to the acceptance of the MF procedure by the AWWA Executive Committee are fully set forth in this statement (p. 72).

Joint Committee on Uniformity of Methods of Water Examination. This agency, established during 1956 and including all national associations engaged in the development of water examination methods, continues its work of comparing the current or proposed texts for examination of water by the various organizations. The value of this activity remains to be learned through experience.

Task Group on Artificial Ground Water Recharge. Operating under the Chairmanship of John J. Baffa, this group will present a final report of the work it now has in hand at the 1958 Conference.

Task Group on Underground Waste Disposal and Control. The task group assigned this subject, under the Chairmanship of Lynn Miller, reported at the 1957 Conference. The report was published in the October 1957 JOURNAL.

ASA Committee B58. This committee, assigned the development of standards for deep well turbine pumps, continues its activities with diligence. The committee had several meetings during the year, devoted in part to the present Standard for Deep Well Vertical Turbine Pumps (ASA B58.1; AWWA A101) and in part to the development of a standard for submersible pumps.

Report on Publications

For the Year Ending December 31, 1957

A report on the publishing activities of the Association for the year ending Dec. 31, 1957, submitted to the AWWA Board of Directors on Jan. 26, 1957, by Eric F. Johnson, Asst. Secretary—Publications.

THE year 1957 was one of exceptional growth for the JOURNAL, both in content and in finances, total pages pushing well beyond the 3,000 mark, while paid advertising approached 1,100 pages and advertising income was $125,000. Only 10 years ago, a 2,300-page JOURNAL carried fewer than 700 pages of advertising, from which income totaled only $52,000.

The year was one of growth for the other publications, too—*Willing Water* increasing in size by 25 per cent and the various books and manuals almost all showing a considerable rise in sales and income as a result of some direct-mail advertising early in the year. With sales of 240,000 and 200,000, respectively, *The Story of Water Supply* and *Your Water Supply* continued to top the list of AWWA bestsellers. And in September another booklet was added to the list with completion of the revised edition of *What Price Water?* in a format that will permit its use as an envelope stuffer or self-mailer. Finally, toward the future, editorial work was started on the steel pipe manual and on the first of the new education manuals.

1. The Journal

A detailed picture of JOURNAL contents, costs, and income for the years 1953–57 is presented in Tables 1 and 2.

a. Contents. As suggested above, the growth in size of the JOURNAL during 1957 was more than had been planned or expected. Estimates for the year had been based on an increase of 128 pages to bring the 1957 text section up to the 1,650-page goal and to make room for some additional abstracts, as well as the expected increase of approximately 50 pages of advertising. When the increase in paid advertising pages more than doubled expectations, the advertising section had to be further expanded, bringing the increase over 1956 up to 192 pages. This made room, too, for the first 100-page abstracts section since 1952.

b. Cost and income. In being larger than expected, the 1957 JOURNAL also cost more than budgeted, but the fact that its extra size was the result of additional advertising meant, of course, additional income that more than compensated for the greater expense. Whereas expenditures exceeded the budget by only 1.6 per cent, advertising income was more than 4 per cent above estimates. Helping to push expenses up, as well as explaining the increase in cost per 1,000 pages, was the large amount of very expensive composition involved in the publication of the 1955 survey of operating data and its analysis. Contributing also

TABLE 1

Journal Contents, Costs, and Income, 1953–57

Item	1953	1954	1955	1956	1957
Contents					
Text pages	1,378	1,366	1,262	1,618	1,646
P&R pages	1,182	1,258	1,282	1,262	1,426
Total pages	2,560	2,624	2,544	2,880	3,072
Text articles					
Conference papers	21	24	23	54	28
Section papers	61	67	90	60	83
Contributions	24	36	19	50	33
Reports & official documents	33	18	13	15	17
Total articles	139	145	145	179	161
Abstract pages	85	75	72	55	100
*Costs**					
Production	$ 4,921	$ 4,598	$ 5,303	$ 8,144	$ 7,505
Printing	47,036	46,182	47,217	55,266	64,238
Paper	14,088	15,207	15,232	19,033	23,284
Total costs	$66,045	$ 65,987	$ 67,752	$ 82,443	$ 95,027
Total-cost index†	100.0	99.9	102.7	125.2	143.9
Cost per copy	47.5¢	46.7¢	45.9¢	53.0¢	57.0¢
Cost per 1,000 pages	$ 2.19	$ 2.09	$ 2.13	$ 2.17	$ 2.19
Printing rate index†	100.0	101.9	101.9	102.5	108.7
Paper rate index†	100.0	102.0	104.1	110.1	118.2
Income					
Advertising	$85,076	$100,951	$107,209	$115,816	$124,889*
Subscriptions	$ 7,510	$ 8,943	$ 9,172	$ 9,879	$ 10,946
Total pages paid advertising	856	926	969	987	1,092
Advertising rate index †	100.0	109.4	109.4	117.7	117.7
Cost per 1,000 circulation	$ 8.30	$ 8.70	$ 8.17	$ 8.34	$ 7.94
Circulation (avg paid per issue)	10,238	10,687	11,281	11,844	12,639
Circulation index†	100.0	104.4	110.2	115.6	123.4

* At variance with audit figures because of different basis.
† 1953 = 100.

TABLE 2

Relation of Journal Cost to Advertising Income, 1953–58

Year	Total Cost $	Advertising Income $	Dollar Spread $	Percentage Spread %
1953	66,045	85,076	19,031	28.8
1954	65,987	100,951	34,964	53.0
1955	67,752	107,209	39,457	58.2
1956	82,442	115,816	33,374	40.4
1957	95,034	124,889	29,855	31.5
1958*	100,000	130,000	30,000	30.0

* Budget figures.

were significant increases in the overall printing and paper rates.

c. The future. With the present number of text pages apparently adequate for the number of papers now suitable for publication, it is expected to continue this section on the same basis during 1958. In expectation of a tapering off in the growth of advertising, partly because of current business conditions and partly as a result of a rate increase effective in January 1958, only a small increase in the advertising portion of the JOURNAL seems probable. Thus, it is expected that total pages in 1958 can be held to 3,104, only 32 pages more than in 1957. Even this small increase in size, combined with the increase in circulation through membership growth and the probable further rises in paper and production prices, is expected to result in an overall cost increase of approximately 5 per cent, bringing the total JOURNAL budget to $100,000 for the year, with advertising income estimated to reach $130,000.

Looking further ahead, the staff has, at the suggestion of the Finance Committee, made a study of JOURNAL advertising rates compared with the rates of other publications in the field, as well as association publications in other fields. The study has confirmed the fact that JOURNAL rates are by far the lowest in the field and has indicated that they are probably a good bit lower than they need to be to encourage a maximum of advertising as an additional source of information to members or to maintain the JOURNAL's noncommercial position in the field. A full report, with recommendations for corrective action, has been submitted to the Finance Committee for study.

2. The Directory

A comparison of the 1957 *Directory* with previous Reference Editions (see Table 3) indicates that, being both larger and more expensive, it was barely able to make ends meet, even with a healthy growth in advertising income. Nevertheless, by virtue of its net cost of −0.1 cent, it became the second *Directory* issue for which income has exceeded costs of printing and production.

TABLE 3

Comparative Data on Directory *Reference Editions, 1953–57*

Item	1953	1955	1957
Total pages	136	176	192
Number of copies printed	12,330	13,990	15,901
Total cost	$4,416	$5,893	$7,384
Cost per 1,000 pages	$ 2.56	$ 2.34	$ 2.37
Cost per copy	35.8¢	42.1¢	46.4¢
Total pages paid advertising	44	57	64
Advertising income	$3,841	$6,266	$7,397
Net cost per copy	4.7¢	−2.7¢	−0.1¢

In 1958, with the much more expensive Membership List Edition scheduled, it is expected that income will cover only half the $15,000 cost, leaving net cost in the neighborhood of 60 cents per copy. Looking toward an eventual reduction of the amount of labor required to publish the membership lists, as well as to a reduction of the possibilities for error, the staff has this year set up a new procedure for verifying *Directory* listings. Just how well the system will work remains to be seen; but the fact that it follows the principle of the telephone company in sending each member a copy of his previous listing for correction may suggest just how big a task this edition of the *Directory* is becoming.

3. Standards and Reprints

New standards issued during 1957 included those on meter testing (C705), the revised and expanded manual for computation of strength and thickness of cast-iron pipe (ASA A21.1, AWWA C101), and a revision of the steel pipe coating standards (C203). Although income from sales of standards was down slightly, from $16,000 to $14,400, the fact that fewer bulk sales were made indicated a considerable increase in the number of sales, and, thus, in the growing popularity of AWWA standards.

Reprint sales during the year jumped more than 45 per cent, from $5,850 to $8,600. As the reasons for this growth were qualitative, they are a little difficult to determine. It appears, however, that no one article or series was responsible; but such useful papers as the "water conditioner" evaluation, the survey of operating data, and the series on the California Water Plan contributed greatly.

4. Willing Water

Still a bimonthly in 1957, *Willing Water* increased its content 25 per cent by the enlargement of three issues to the 12-page size. Again a greater variety of subject matter was included, public relations material being supplemented by articles on water policy, standards, fluoridation, highway relocation problems, and safety. In all, three conference and seven section meeting presentations were included with the usual special feature material. The additional pages and additional copies, plus an increase in printing and mailing costs, boosted the 1957 *Willing Water* expenditure to $7,100, compared with approximately $5,000 in 1956 and earlier years.

The direction in which the *Willing Water* bulletin should move in the future is not now entirely clear. Certainly it must play an important part in the new public information program as a means of keeping water utilities supplied with material and ideas for their cooperative activity. On the other hand, in such items as the statements on water resources policy, standards, highway legislation, and the abstract of the fluoridation panel, it has proved itself a most useful medium for getting information to the membership in a hurry. With the thought of answering both these requirements and providing as well a forum for the dissemination of information of the "actual experience" type, consideration has been given to the possibility of expanding *Willing Water* to a monthly publication of perhaps 16 pages, which would include not only such material as noted above but the promotional material on conventions and book sales, special bulletins on defense, reports on board

meetings, and similar material now issued as separate brochures or broadsides. Set up on this basis and entered as second-class matter, to reduce mailing costs, 192 pages of *Willing Water* per year—that is twelve 16-page issues—could be distributed at a cost of approximately $17,000. Actually, this would mean a net increase of less than $6,000 in expenditures, for the cost of *Willing Water* plus convention promotion and other special bulletins during 1957 totaled approximately $11,600. It is felt that such an expanded *Willing Water* would make a very worthwhile addition to the benefits of AWWA membership.

In view of the fact that such a change in *Willing Water* must be coordinated with the public information activities approved by the Board (see the Public Information Committee report appearing in this issue, p. 453), that the production details and the printing contracts to make the change will require some time, and that a reorganization of staff assignments and time will be required, it is felt that the proposed expansion cannot be undertaken at least until July 1958. [The Board approved both the expansion and the necessary budget to permit it to go into effect in the latter part of 1958.]

5. Booklets

Combined distribution of the three booklets now available for the use of AWWA members in their public relations activities approached the half-million mark in 1957. And, of this distribution, the new *What Price Water?* had time to contribute only about 40,000, indicating the continuing popularity of the old favorites. A summary of booklet sales, cost, and income figures is presented in Table 4.

a. The Story of Water Supply. Although no special promotion other than the normal followup of teacher requests was undertaken during the year, 240,000 copies of the booklet were sold.

TABLE 4

Summary Data on Public Relations Booklets Through 1957

Booklet	No. Printed	No. Sold	Inventory	Production & Sales Expense $	Income $	Inventory Value $
Story of Water Supply	1,200,000	1,108,800	91,200	29,715.37	48,642.18	1,632.48
Your Water Supply	920,585	874,485	46,100	14,721.27	22,422.97	597.00
What Price Water?	50,000	40,600	9,400	1,880.51	882.37	207.18

Repeat orders constituted a large part of these sales, but it is expected soon to do some further promotion to bring the usefulness of this tool to the attention of additional members.

b. Your Water Supply. Through the mailing of a copy of a slightly revised *Your Water Supply* to each member in August, sales of this booklet were increased to the point where three printings, totaling 230,000 copies, were required during the year. Although the printing cost for these copies was increased by 70 cents per 1,000, the price to members was not raised. The imprinting price schedule, however, had to be revised, as the im-

printing procedure was changed to improve service.

c. What Price Water? Issued in September was a 12-page 4 × 9-in. booklet entitled *What Price Water?* A revision of a brochure originally published 10 years ago, the text of this booklet is designed to assist water utilities in convincing their customers of the importance of water supply and the need for higher rates. Suitable for enclosure in a standard business envelope or for use as a self-mailer, the new booklet was introduced to members by a sample sent out with the October *Willing Water* mailing.

ties for their public relations activities are a number of other aids, which include newspaper mats and electrotypes, posters, postal meter advertisements, decalcomanias, novelties, and various *Willing Water* reprints. Sales of all these increased during the year, following the issuance of a new catalog in October. The items continue to be a useful, if relatively minor, addition to the services provided by the Association.

6. Books

The order form for other books that accompanied the announcement of the *1940–55 Journal Index* in February

TABLE 5

Summary Data on Current AWWA Books and Manuals

Year Published	Book	No. Printed	No. Bound	No. Sold	Inventory		Production & Sales Expense $	Income $	Value of Inventory on Hand $
					Bound	Unbound			
1938	*Manual of Accounting*	1,898	1,898	1,740	158		3,437.09	6,058.65	235.42
1946	*Survival and Retirement*	3,006	2,509	2,217	292	496	5,175.50	6,297.17	975.07
1948	*Quest for Pure Water*	2,512	2,021	1,821	200	491	8,730.30	7,802.63	897.35
1950	*Water Quality and Treatment* (2nd edition)	9,300	5,533	5,194	339	3,757	15,144.78	22,525.82	2,319.20
1956	*1940–55 Index*	3,500	1,500	667	833	2,000	4,393.81	2,668.55	2,431.72
	Manual								
1954	*Water Rates* (M1)	2,200	2,200	1,331	869		984.60	1,318.60	205.08
1955	*Silent Service* (M2)	5,038	2,538	614	1,924	2,500	1,060.11	655.62	769.18
1956	*Safety Practice* (M3)	3,000	3,000	1,728	1,272		1,356.51	2,099.95	525.39

Although this edition was specifically designed to sell at low enough prices (ranging down to less than 2.5 cents per copy) to attract wide distribution, orders to date have almost all been for small lots, presumably for special rather than general distribution. It is still too early to tell, however, whether or not *What Price Water?* will prove as useful a public relations tool as the earlier booklets.

d. Other public relations aids. In addition to the booklets offered to utili-

1957 resulted in an increase in sales of all books over the 1956 record. Although no additional books were published during the year, the index was new as far as sales are concerned, and there were new bindings required for both *Water Quality and Treatment* and the *Survival and Retirement* book. Complete sales and financial data on the five current titles published by the Association are included in Table 5, and reviewed below is the 1957 record of each of these books and of *Standard*

Methods, which is distributed by the American Public Health Association:

a. Manual of Water Works Accounting. Sales: 118 copies in 1957; 87 in 1956; 121 in 1955; 84 in 1954; 32 in 1953.

b. Survival and Retirement Experience With Water Works Facilities. Sales: 105 copies in 1957; 43 in 1956; 103 in 1955; 68 in 1954; 51 in 1953.

c. The Quest for Pure Water. Sales: 97 copies in 1957; 48 in 1956; 84 in 1955; 77 in 1954; 52 in 1953.

d. Water Quality and Treatment. Sales: 482 copies in 1957; 423 in 1956; 544 in 1955; 539 in 1954; 425 in 1953.

With only 339 copies on hand at the end of the year, a new binding may be required during 1958. It is now more than 7 years since this book was published and more than 8 years since the text was written. In that time there have been many changes in water treatment practice—many more than have been covered in the revised chapters on filtration, sedimentation, and aeration now being distributed with the book. If the book is to keep its reputation as an authoritative text on water treatment and its customers as a college textbook, work on the third edition should be undertaken during 1958. The Water Works Practice Committee has this recommendation in mind and action on the matter is impending. (Although a considerable stock of the second edition remains, these books do not represent any large investment. They are unbound copies that were run off in a larger quantity than necessary to permit releasing the type metal at a time when that was scarce. They should not now be considered an argument for delaying a new edition.)

e. Index to Journal AWWA (1940–55). Sales of the new JOURNAL index, which was issued in late December 1956, totaled 664 copies during 1957, falling a little short of staff hopes, if not expectation. Since the hopes of the staff are based in some part on the conviction that its load of inquiries could be reduced tremendously if members had, and used, the index, its 1,000 goal for 1957 was apparently 34 per cent wishful thinking. At any rate the index as a key to 16 years of valuable information will undoubtedly be in demand for a number of years, during which it is expected that the income will catch up with production and sales expense.

Of the *1881–1939 Index,* 60 copies were sold, leaving only 34 in stock.

f. Standard Methods for the Examination of Water, Sewage, and Industrial Wastes. Sales of the tenth edition during 1957 totaled 3,240 copies, bringing total distribution of that edition to slightly more than 15,000 in the 3 years since its publication, compared with sales of 22,000 for the ninth edition in 9 years.

The tempo of activity on the eleventh edition increased during the year, the Joint Editorial Board meeting twice and carrying on an active correspondence between meetings. At its meetings a detailed schedule keyed to publication of the new edition in 1960 and a procedure for development, review, and approval of the methods to be included were established. Meanwhile, within the AWWA Standard Methods Committee, Chairman Michael J. Taras has been especially busy in getting his various subcommittees in motion to meet a Jan. 1, 1959, deadline for submission of all methods. One of the methods proposed for inclusion in the new edition—that for methane—was published in the August 1957

JOURNAL, and in the coming year other newly proposed methods are scheduled to appear.

7. Manuals

Like the books, the manuals profited in sales by advertisement on the direct-mail order form. Their full sales and financial records are included in Table 5.

a. Water Rates Manual. Sales: 476 copies in 1957; 167 in 1956; 478 in 1955; 210 in 1954. To meet the demand of sales that matched its best year, a new printing of 1,200 copies of this manual was produced. As the Association owns the type, it will be possible to keep this title in stock continuously.

b. Silent Service Is Not Enough! Sales: 259 copies in 1957; 43 in 1956; 312 in 1955. Although sales of this manual improved with promotion during the year, the book is one that should be more generally used. It may be expected that the public information campaign will help in calling its availability to the attention of those who need it.

c. Safety Practice Manual. Sales: 738 in 1957; 990 in 1956. In its second printing already, this manual promises to maintain its popularity as the safety award program and other activities of the Safety Committee continue. On this manual, too, the Association owns the type and will, thus, be able to continue reprinting as long as the demand continues.

d. Steel pipe manual. At the end of the year, editorial work on the new steel pipe manual, which will be more or less a counterpart of the cast-iron pipe manual (ASA A21.1, AWWA C101), was begun. Estimated to total 200 pages and cost approximately $6,000, this manual will be a major editorial job. Working together with Russell E. Barnard, who has been the editorial coordinator for the committee, however, the staff expects to get this addition to the list of AWWA manuals into print before the end of 1958.

e. Educational manuals. Because a large amount of duplication was involved in the original outline of six short-course manuals, the Education Committee, at its meeting during the 1957 Annual Conference last May, agreed to consolidate the material available into four manuals covering the field: development of water supply, treatment of water, distribution of water, and water utility management. Of these four, the management manual has been all but completed and is now in the hands of the editorial staff. The distribution manual at the moment is in the hands of a technical coordinator, whose work can be completed as required by the editorial staff. The other two manuals will not be available for publication until 1959.

Tentatively, a budget of $2,500 has been suggested for 1958. This estimate is based on the assumption that only the management manual will be completed during the year. Although the desirability of getting these manuals into circulation at the earliest possible date is well recognized, the job of editing such compilations of contributions is anything but a routine one. Under the present setup, there is a shortage of staff capable of undertaking the job and, in competition with the proposed expansion of *Willing Water*, the publication of the Membership List Edition of the *Directory* under a new system, the production of the steel pipe manual, and the undertaking of an un-

known quantity of publication activity in connection with the public information program, the job's being done depends upon the priority assigned in planning the time of the staff. A particular effort will be made, however, to get the management manual into print during 1958.

8. Staff

A limiting factor in too many of the publication activities appears to be staff time. Staff time, of course, represents money, but many of the activities that await doing could undoubtedly pay for themselves and the staff time involved. Various means of augmenting staff time for important activities, such as reorganization of the publication staff, have been considered, but because the nature of the new public information program will have an important effect upon staff activities as a whole, definite reorganization must be based on the changes thereby effected. In any case, the growth of the Association, of the publications themselves, and of the production and advertising activities connected with them, together with the new publications projects into which the Association could profitably enter, have combined to make it necessary to increase the staff in the near future. [To provide for this growth factor, as well as the proposed expansion of *Willing Water*, the Board approved the employment of an additional staff member.]

Report of the Audit of Association Funds

For the Year Ending December 31, 1957

To the Members of the American Water Works Association:

The By-Laws require that the Secretary have an audit made annually of the books of the Association.

The records for 1957 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Audits have been published in the JOURNAL annually since 1937. They have appeared either in the March or April issue.

Respectfully submitted,
HARRY E. JORDAN
Secretary

January 28, 1958

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1957, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet as of December 31, 1957, and the related statements of income and surplus present fairly the financial position of the American Water Works Association at that date and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)
LOUIS D. BLUM & Co.
Certified Public Accountants

EXHIBIT A—BALANCE SHEET

DECEMBER 31, 1957

Assets

Cash in Banks and on Hand		$ 56,512.28
Accounts Receivable:		
Membership dues	$ 924.50	
Advertising—Journal	10,763.94	
Reprints	1,576.77	
Sundry standards	912.41	
The Story of Water Supply (booklet)	1,270.42	
Your Water Supply (booklet)	1,517.95	
Other	851.39	17,817.38
Accrued Interest on Bonds		1,101.16
Inventories		
Paper stock	12,017.00	
Type metal	2,940.02	
Water Quality and Treatment (book)	2,319.20	
Manual of Water Works Accounting (book)	250.32	
Water Rates Manual (manual)	205.08	
Sundry standards	2,946.56	
Quest for Pure Water (book)	897.35	
Survival and Retirement (book)	975.07	
Willing Water novelties	222.15	
Cumulative Index—1881–1939	40.80	
Cumulative Index—1940–1955	2,431.72	
Your Water Supply (booklet)	597.00	
The Story of Water Supply (booklet)	1,632.48	
Silent Service Is Not Enough! (manual)	769.18	
Safety Practice for Water Utilities (manual)	525.39	
What Price Water (booklet)	207.18	
Back Issues—Journal—Vol. 1–49, inclusive (42,852 copies)	—*	
Back Issues—Proceedings—1881–1913, inclusive (240 copies)	—*	28,976.50
Office Equipment (less depreciation)		18,095.09
Investments at Cost (Schedule 1)		147,745.60
Deferred Expenses		4,311.65
Deposits—Airlines and Postage		589.68
TOTAL ASSETS		$275,149.34

Liabilities and Surplus

Accounts Payable	$ 12,048.50
Membership Dues—Advance Payments	59,865.70
Unearned Subscriptions to Journal	4,999.43
Unearned Advertising	2,916.17
Payable to American Water Works Association Pension System	10,000.00†
Reserve for Award Fund (McCord)	53.02
Senior Members Contributory Fund	4,234.56
Miscellaneous	186.13
Surplus, per Exhibit C	180,845.83
TOTAL LIABILITIES AND SURPLUS	$275,149.34

* Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication. The quantity shown is in accordance with a tabulation supplied by the Association's printer.

† Secured by the assignment of the income of a U. S. Savings Bond, Series G, and maturity redemption value of such bond in the amount of $10,000.00.

EXHIBIT A, SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1957

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1957
Foreign Securities:				
Province of Ontario	4	$ 1,000.00	$ 732.50	$ 997.50*
Dominion of Canada, 6th Victory Loan	3	2,000.00	2,000.00	1.988.75†
Hydro Electric Power Commission of Ontario	2.75	5,000.00	5,075.00	4,437.50†
Province of Ontario	3	2,000.00	2,022.50	1,867.50†
Hydro Electric Power Commission of Ontario	3	2,000.00	2,020.00	1,857.50†
Dominion of Canada	3	5,000.00	4,775.00	4,787.50†
United States Securities:				
US Savings Bonds, Series:				
G	2.5	10,000.00	10,000.00	9,860.00‡§
G	2.5	3,000.00	3,000.00	3,000.00‡
G	2.5	12,000.00	12,000.00	11,832.00‡
G	2.5	7,000.00	7,000.00	6,874.00‡
G	2.5	7,500.00	7,500.00	7,297.50‡
G	2.5	2.500.00	2,500.00	2,402.50‡
G	2.5	1,000.00	1,000.00	958.00‡
K	2.76	5,000.00	5,000.00	4,830.00‡
K	2.76	2,000.00	2,000.00	1,938.00‡
K	2.76	20,000.00	20,000.00	19,380.00‡
K	2.76	5,000.00	5,000.00	4,845.00‡
K	2.76	10,000.00	10,000.00	9,710.00‡
K	2.76	10,000.00	10,000.00	9,920.00‡
US Treasury Bond	4	10,000.00	10,000.00	10,825.00‡
US Treasury Bill		10,000.00	9,920.60	9,942.35‡
Utilities:				
Consumers Power Company Bonds	4.75	5,000.00	5,431.25	5,406.25
Pacific Gas and Electric Co. Bonds	4.50	5,000.00	5,362.50	5,293.75
American Telephone and Telegraph Bonds	5	5,000.00	5,406.25	5,406.25
		$147,000.00	$147,745.60	$145,656.85

* This security is payable in United States funds.
† These securities are payable in Canadian funds. Market value represents value in New York in United States funds.
‡ These amounts represent redemption value on Dec. 31, 1957.
§ Redemption value and income of this security assigned to American Water Works Association Pension System.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES
FOR THE YEAR ENDED DECEMBER 31, 1957

Operating Income:	
Annual dues	$127,594.47
Advertising—Journal	124,765.94
Advertising—Directory	7,396.50
Subscriptions to Journal	10,835.15
Convention:	
Registration fees	35,237.50
Ticket sales	3,379.25
Other events	60.00
OPERATING INCOME (carried forward)	$309,268.81

OPERATING INCOME (brought forward)		$309,268.81	
Water and Sewage Works Manufacturers Assn.		7,500.00	
Interest and dividends on investments		4,239.01	
Miscellaneous income		255.61	
TOTAL OPERATING INCOME			$321,263.43
Publication Income:			
Water Quality and Treatment (book)		1,979.16	
One-third of profit from sales of Standard Methods (book)		4,710.59	
Manual of Water Works Accounting (book)		405.60	
Water Rates Manual (manual)		475.75	
Sundry standards		14,806.86	
Proceedings and Journals		1,541.51	
Quest for Pure Water (book)		414.70	
Survival and Retirement (book)		265.20	
Willing Water novelties		473.58	
Reprints		9,552.45	
Silent Service Is Not Enough! (manual)		323.30	
Public relations material		268.40	
Your Water Supply (booklet)		5,282.65	
The Story of Water Supply (booklet)		9,447.29	
Cumulative Index—1881–1939		69.20	
Cumulative Index—1940–1955		2,659.80	
Safety Practice for Water Utilities (manual)		914.60	
What Price Water (booklet)		944.42	
Miscellaneous		42.05	
TOTAL PUBLICATION INCOME			54,577.11
TOTAL INCOME (carried forward)			$375,840.54
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense	$ 8,675.61		
Stenographic expense	311.60	$ 8,987.21	
Administrative Expenses:			
Rent	13,500.00		
Office supplies and services	18,196.28		
Membership promotion	608.56		
Pension—Secretary Emeritus	2,500.00		
Contributions to pension system	6,840.70		
Legal and auditing expenses	6,807.40		
General and special travel	3,073.43		
Federal activities	323.97		
Social security taxes	827.07		
Secretary's special expense	2,500.00	55,177.41	
Administrative Salaries		99,626.07	
Committee Expense		2,095.72	
Division and Section Expenses:			
Section—membership allotment	23,088.76		
Section—travel expense	5,871.23		
Section—general expense	857.59	29,817.58	
OPERATING EXPENSES (carried forward)		195,703.99	

TOTAL INCOME (brought forward)			$375,840.54
OPERATING EXPENSES (brought forward)		$195,703.99	
Journal:			
Printing	64,046.69		
Production	7,903.88		
Paper	23,283.61		
Directory	7,074.85	102,309.03	
Convention:			
General	11,776.12		
Entertainment	19,013.03	30,789.15	
Membership Dues in Other Associations		2,638.00	
Depreciation of Office Equipment		2,710.78	
Miscellaneous		1,298.55	
TOTAL OPERATING EXPENSES		$335,449.50	
Cost of Publications Sold:			
Water Quality and Treatment (book)	$ 802.17		
Standard Methods (book)	375.73		
Manual of Water Works Accounting (book)	211.46		
Water Rates Manual	159.51		
Sundry standards	5,907.21		
Proceedings and Journals	53.75		
Quest for Pure Water (book)	207.55		
Survival and Retirement (book)	201.07		
Willing Water novelties	436.71		
Reprints	6,400.76		
Silent Service Is Not Enough! (manual)	144.25		
Public relations material	1,108.91		
Your Water Supply (booklet)	3,526.44		
The Story of Water Supply (booklet)	5,279.75		
Cumulative Index—1881–1939	72.00		
Cumulative Index—1940–1955	1,821.25		
Safety Practice for Water Utilities (manual)	251.79		
Special handling and postage charges	1,948.29		
What Price Water (booklet)	1,673.33		
In Service Training Manual	102.10		
Miscellaneous	9.70	30,693.73	
Development Activities:			
Public relations	6,423.32		
Research promotion	3,941.93		
1955 Operating Survey	500.00		
General publicity	1,355.12		
Safety awards	1,054.53	13,274.90	
TOTAL EXPENSES			379,418.13
Net Income for the Year (Transferred to Exhibit C)			$ (3,577.59)*

* Negative figure.

EXHIBIT C—STATEMENT OF SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1957

Balance, January 1, 1957	$184,423.42
Add: Net income for the year, per Exhibit B (loss)	(3,577.59)
Balance, December 31, 1957, per Exhibit A	$180,845.83

American Water Works Association Pension System

BALANCE SHEET— DECEMBER 31, 1957

Assets

Cash in bank	$ 1,321.00
Accrued bond interest	783.33
Investments (Schedule 1)	119,873.75
TOTAL ASSETS	$121,978.08

Liabilities and Reserve for Future Benefits

Liability for refund of employees' contributions plus earned interest	$ 11,875.76
Reserve for future benefits	110,058.57
Due to American Water Works Association	43.75
TOTAL LIABILITIES AND RESERVE	$121,978.08

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR 1957

Item	Cash	Reserve for Future Benefits	Liability for Refund of Employees' Contributions	Due to AWWA
Receipts:				
Association contributions	$ 6,840.70	$ 6,840.70	$ —	$ —
Employees' contributions	2,117.89	—	2,117.89	—
Interest on bonds	$ 2,793.31	2,749.56	—	43.75
Interest on savings account	115.46	115.46	—	—
Total	11,867.36	9,705.72	2,117.89	43.75
Disbursements:				
Investment in bonds	11,873.75	—	—	—
Refund of contributions plus interest	328.35	—	328.35	—
Audit and legal expense	50.00	50.00	—	—
Office expenses	91.90	91.90	—	—
Total	12,344.00	141.90	328.35	—
Excess of Cash Disbursements Over Receipts	(476.64)*	9,563.82	1,789.54	43.75
Adjustments for Non-Cash Items:				
Interest credited to employees accounts	—	(293.40)*	293.40	—
Interest accrued on bonds, Jan. 1, 1957	—	(673.95)*†	—	—
Interest accrued on bonds Dec. 31, 1957	—	783.33‡	—	—
	—	(184.02)*	293.40	—
Additions to accounts for year	(476.64)*	9,379.80	2,082.94	43.75
Balance, January 1, 1957	1,797.64	100,678.77	9,792.82	—
Balance, December 31, 1957	$ 1,321.00	$110,058.57	$11,875.76	$43.75

* Negative figure.
† Accrued interest receivable as per balance sheet Dec. 31, 1956.
‡ Accrued interest receivable as per balance sheet Dec. 31, 1957.

SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1957

Description	Interest Rate %	Cost	Maturity Date
Bonds Registered in Name of Administrative Committee:			
Series G	2.5	$ 10,000.00*	1961
Series G	2.5	10,000.00*	1962
Series G	2.5	14,000.00*	1963
Series K	2.76	9,000.00*	1964
Series K	2.76	17,000.00*	1965
Series K	2.76	9,000.00*	1966
Series K	2.76	9,000.00*	1967
Series K	2.76	20,000.00*	1968
Consumers Power Company bonds	4.75	5,393.75†§	1987
American Telephone & Telegraph bonds	5	6,480.00‡§	1983
Bond Registered in Name of Association and Assigned to Administrative Committee:			
Series G	2.5	10,000.00	1958
Total		$119,873.75	

* Redemption value on Dec. 31, 1957:$95,066.00.
† Market value on Dec. 31, 1957:$5,406.25.
‡ Market value on Dec. 31, 1957:$6,487.50.
§ Acquired in 1957.

1957 Section Membership Awards

Old Oaken Bucket		Hill Cup		Henshaw Cup	
Section	Score*	Section	Score†	Section	Score‡
California	1,424	Iowa	30.264	Pacific Northwest	70.6
Southwest	1,031	Rocky Mountain	27.497	Rocky Mountain	64.1
New York	866	Kentucky-Tennessee	19.198	Arizona	59.5
Canadian	700	New Jersey	18.585	Iowa	58.6
Illinois	616	Indiana	18.208	Montana	57.5
Pennsylvania	551	Canadian	17.980	Ohio	55.3
Indiana	508	California	17.625	Wisconsin	51.9
Ohio	497	Pacific-Northwest	16.110	Indiana	47.5
New Jersey	493	Michigan	16.056	North Carolina	46.9
Pacific-Northwest	462	Montana	15.984	Southeastern	42.7
Michigan	452	Illinois	15.827	Alabama-Mississippi	42.4
Florida	330	Southeastern	14.260	West Virginia	41.9
Southeastern	304	Kansas	13.320	Kansas	41.8
Chesapeake	282	Chesapeake	12.980	Kentucky-Tennessee	38.9
North Central	259	Arizona	10.500	Michigan	38.2
New England	258	Ohio	8.856	Virginia	36.2
Kentucky-Tennessee	248	Missouri	7.766	Nebraska	35.8
Kansas	235	New York	7.424	New York	34.2
Missouri	227	Cuba	7.248	Chesapeake	34.0
North Carolina	220	New England	6.732	New Jersey	33.9
Alabama-Mississippi	217	Virginia	6.728	Florida	31.3
Rocky Mountain	213	Alabama-Mississippi	5.628	North Central	30.5
Virginia	210	Wisconsin	5.558	Illinois	30.2
Wisconsin	201	North Central	2.552	Southwest	28.8
Iowa	179	Pennsylvania	2.296	Pennsylvania	20.4
Nebraska	106	Florida	§	California	‖
West Virginia	96	Nebraska	§	Canadian	‖
Arizona	84	North Carolina	§	Cuban	‖
Montana	62	Southwest	§	Missouri	‖
Cuban	57	West Virginia	§	New England	‖

* Numbers of members.
† Weighted gain in membership.
‡ Percentage of members present at annual meeting.
§ Minus score.
‖ Data not available or section not competing.

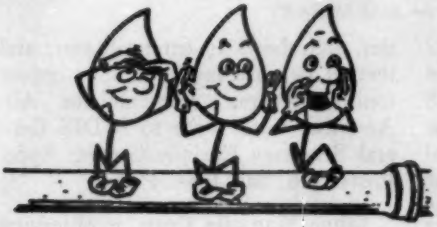
AWWA Membership Growth

Membership Statement—Year of 1957

	Active	Corporate	Munic. Serv Subscriber	Associate	Honorary	Life	Junior	Total
Total members, Dec. 31, 1956....	9,113	922	246	364	41	337	50	11,073
Change of grade, 1957.....	−42				4	41	−3	
	9,071	922	246	364	45	378	47	11,073
Gains:								
New, 1957.....	1,292	65	36	12		2	19	1,426
Reinstated, 1957.....	83	6	4	2				95
	10,446	993	286	378	45	380	66	12,594
Losses:								
Resignations and deaths, 1957..	−206	−8	−1	−8	−3	−16	−1	−243
Dropped for nonpayment, 1957.	−632	−43	−14	−5			−5	−699
TOTAL MEMBERS, Dec. 31, 1957..	9,608	942	271	365	42	364	60	11,652
Net Gain in 1957.....	495	20	25	1	1	27	10	579

Comparative Statement—Gains and Losses—25-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of Dues	Gain or Loss	Total Members at End of Year
1933	168	56	159	234	169−	2,221
1934	271	66	86	122	129+	2,350
1935	565	42	85	190	332+	2,682
1936	311	53	104	218	42+	2,724
1937	515	86	122	139	340+	3,064
1938	520	59	144	140	295+	3,359
1939	578	64	122	179	351+	3,710
1940	514	58	113	212	247+	3,957
1941	480	92	116	236	220+	4,177
1942	570	59	132	233	264+	4,441
1943	769	88	130	198	529+	4,970
1944	734	92	140	171	515+	5,485
1945	543	56	111	235	253+	5,738
1946	816	79	168	324	403+	6,141
1947	933	74	143	349	515+	6,656
1948	847	81	207	347	374+	7,030
1949	1,083	75	196	323	639+	7,669
1950	852	58	128	421	361+	8,070
1951	1,090	63	199	441	513+	8,583
1952	1,005	66	232	505	334+	8,917
1953	1,077	99	263	370	543+	9,460
1954	1,160	69	256	493	480+	9,940
1955	1,244	90	270	578	486+	10,426
1956	1,424	118	284	611	555+	11,073
1957	1,425	96	243	699	579+	11,652



Percolation and Runoff

DAWWAS is what they will be calling Big D for the week of Apr. 20–25 when 3,000 water works men and their wives take over the town, from the halls of Memorial Auditorium to the stores of Neiman-Marcus. And this 78th of AWWA's annual conferences promises to be first in fact, fun, and fellowship, the Southwest Section hosts having given their AWWA duties highest priority for many, many months. Out of their endeavors have come: fifteen technical sessions crammed full of information and interest; a 200-booth exhibit wherein at least 100 manufacturers will spread their finest wares; four evenings of entertainment planned and executed in true Texas tempo; and a host of other attractions as well as distractions—committee meetings, bull sessions, parties, tours, steaks—the works! As a matter of fact, we've even heard it rumored that those sunshading Southwest hats are, in honor of Water Works Week 1958, to be called ten-gallon hats!

Texas is BIG, Big D is BIG—there's room for everyone—there's plenty for everyone—come to DAWWAS!

But if you can't come, LISTEN—North American Van Lines will be blinking its headlights our way in a Salute to the Water Works Field on NBC-Monitor, Sunday afternoon, Apr. 20. It will be Alex Dreier, noted radio commentator, who does the honors, but you'll be the star of the show. And Water Works Week 1958 will be getting a real sendoff with at least 2,000,000 of our customers.

The lifeblood of the community is what AWWA is calling water these days in its new public information program, and just how accurate a description that is can be demonstrated in all kinds of ways. It was shown, for instance, in the water consumption records of Cleveland from October 1957 to January 1958, when with the recession in industrial activity, the city's water use dropped approximately 3 per cent below that of the previous year in each month until January, when the falloff was 7 per cent—total consumption being 8,649,935 gal this January compared to 9,316,523 gal last year. That this slow pulse may very well be psychosomatic makes the demonstration nonetheless convincing. After all, at times a community, or even a country, gets all wet between the ears.

At Jersey City, N.J., meanwhile, the bloodiness was definitely traumatic—a

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ruptured 36-in. artery spilling some 22 mil gal and causing the shutdown of 195 plants and businesses and 18 schools for up to 2 days while the wound was being isolated and normal pressure restored in the rest of the system. With February temperatures far below freezing, with the story of the emergency situation and the hapless hunt for its cause carried on the front pages of New York as well as New Jersey newspapers, with the break in 8 ft of mud under the Hackensack River, and with a defective valve at the crossing, the city's faint pulse was accompanied by a high fever in its water department until the bleeding could be stopped.

And at Rensselaer, N.Y., the problem was pathogenic, the city's lifeblood being contaminated by bacteria from the sewage of upstream Hudson River communities with which the Rensselaer treatment plant, built in 1900, could no longer cope. Ordered by the county health department to boil drinking water until emergency disinfection measures could be made effective, the community was faced with some serious therapeutic action—to provide a new, adequate treatment plant or to find a new, uncontaminated source of supply to substitute for the Hudson River supply that had been ordered abandoned as long ago as 1952.

Blood tells, they say—and telling is the way to public information.

An All-American rating is what AWWA will be working toward next May 18–24 at San Juan, Puerto Rico, when it sets up a "Join AWWA" booth at the Sixth Congress of the Inter-American Association of Sanitary Engineering (AIDIS). Half the program will be on water and sewage; there'll be tours, receptions, races, parties, and shows to entertain you; and there'll be postconvention tour opportunities galore. For all the All-American facts, write to AIDIS General Secretary Enrique Ortega, Apdo. Postal 218, San Juan, P.R.

Johns-Manville Corp. is observing its 100th anniversary this year. The organization was founded in 1858 by H. W. Johns, a 21-year-old New England farm boy, who started out in Brooklyn, N.Y., as a jobber of paints and coatings for roofs. That same year he established a basement workshop "factory" at 120 Wall St., New York City, where he began the manufacture of his own line of roofing materials. Within a few years, Johns had pioneered the present worldwide, billion-dollar asbestos industry by the introduction of asbestos fiber, obtained from deposits on Staten Island, N.Y., into an "improved portable roofing" which rapidly came into wide use. A financial statement dated 1862 put capitalization of the H. W. Johns Co. at $10,000. He introduced his asbestos roofing in 1868, and by 1874, the business had acquired a Dun & Bradstreet credit rating of "good up to $100,000."

H. W. Johns

C. B. Manville

H. W. Johns died in 1898, after he had led the company safely through the 5 years of deep depression that began in 1893. In 1901 the Manville

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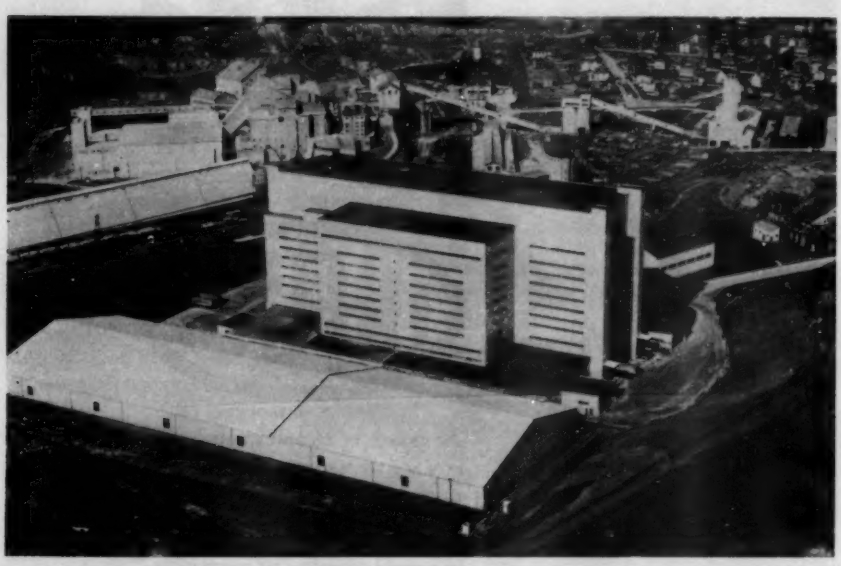
Covering Co. of Milwaukee, founded by C. B. Manville and his three sons in 1886, was merged with the H. W. Johns Mfg. Co. to form the Johns-Manville organization. It began operating as such on Jan. 1, 1902, with T. F. Manville Sr., one of the sons, as president. He led the combined companies for 24 years, running the annual sales volume up to $40,000,000 before he died in 1926.

The original H. W. Johns basement factory in New York, which he personally operated by muscle power with one helper, under light from a whale-oil lamp, has grown into a string of 26 highly mechanized modern plants and four mines in the United States, Canada, Belgium, and Southern Rhodesia, with about 21,700 employees and about 20,000 stockholders. Johns-Manville buys over $130,000,000 worth of raw materials, goods, and services every year from more than 14,000 suppliers throughout the United States and Canada. The company pays close to $27,000,000 in taxes each year.

With annual sales around the $300,000,000 mark and still growing, and a yearly payroll in excess of $115,000,000, Johns-Manville is not one big company but an organization of several small companies. It actually is engaged in about eighteen different, well diversified businesses in the industrial-products, construction industry, and modernization materials fields. There are nine operating divisions



More than 100 years of asbestos ore reserve is located at the Johns-Manville mine and mill at Asbestos, Que. The largest asbestos mine in the world, it is the source of about one-third of the free world's supply of asbestos fiber.

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A. R. Fisher

C. B. Burnett

with decentralized responsibility under coordinated corporate control. Each division is responsible for its own production, sales, and profits. Current board chairman and president is A. R. Fisher, with C. B. Burnett executive vice-president and director.

Good for what ails you, we feel, can be said of almost any public water supply, but we must admit that there are certain waters that have long had a reputation of more than ordinary therapeutic powers. Of these, some have been sold in bottles, others in resort bathtubs or other expensive forms, and, on occasion, some have even gone uncommercialized. Such, apparently, is true of a well water at a forest preserve on the outskirts of Chicago for which people line up at all hours of the day and night, because, they say, the water makes them feel better. Such must be true, too, of the water supplied by the Fayetteville, N.C., water system, at least as far as one of its consumers is concerned. Writing to system manager D. J. Gore, Mrs. Eelma B. Brown of Washington, D.C., reported that, on a visit to Fayetteville, she had found that "a physical condition" she had, had "responded favorably to the soft type of water" and ordered two 5-gal jars sent to her in Washington. Similar stories of signal salubriousness in city supplies have been told before and, undoubtedly, there will be others to gladden our heart in the future, but we doubt that we shall often have the opportunity to report on a water supply that is not only good for what ails you, but good for what fails you. This is the story of the water of Ixtapan de la Sal, a fairly new resort approximately a 2-hr drive from Mexico City. Radioactivated, the supply is reported to cure "everything"—gout and inflammations, arthritis and melancholy, hangover and obesity—but more than that, much more than that, in the words of the waiter who served Stan Delaplane, Houston *Post* columnist, on a recent visit there:

> The waters have great effect against age. They are filled with the same thing they put in the bomba atomica. As one grows old, it is necessary to barricade and take care of the future. The years pass swiftly. One must think of the familia, no? Why, Senor, old, old men come here—tottering, barely alive. They go home like lions. The eyes sparkle. The face is flushed. They return next year with a new child in the family. It is a wonder of Ixtapan.

The Ixt wonder is something that probably can't be matched by any public water supply. As a matter of fact, judging from the difficulty experienced by most of them in keeping up with even unactivated population growth, it's probably just as well. But we need only recall that old slogan, "The only safe water is a sterilized water!," to guess that it must be chlorine that puts us out of the running. With chlorine, apparently the best (or worst) a public water supply has been able to do is to cause morning sickness. That hap-

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pened just last month in one of our eastern cities, causing considerable concern to five women who recognized the symptoms. It took the water utility manager considerable explaining and activated carbon to arrest the apparent pregnancies.

Meanwhile, we invite you all to stop at Dallas Apr. 20–25 on your way south. It will be good for what entails you!

Jones, Henry & Williams, consulting engineers, announce that the following have become members of the partnership: Harry E. Heck, Ellis M. Keeler, Harold A. Kelley, Coburn C. Metcalf, Cecil B. Russell, and Roger W. Stevens.

Water resources and supply was the subject of a number of papers presented at the recent ASCE convention in Chicago. Murray Stein, chief of the Interstate Enforcement Section, Water Supply & Water Pollution Control Program, USPHS, pointed out that water, long a critical resource in the seventeen western states, is approaching the same status in the East as well. This trend brings with it a need for review and revision of water policies in the eastern states in order to assure equitable apportionment, improved quality, and stabilization of flows and supply. Mr. Stein indicated that the National Conference of Commissioners on Uniform State Laws has undertaken the task of preparing a model water use act for consideration by the states. The technical work has been assigned to the University of Michigan Law School. As now being discussed, the proposed model act would: [1] establish a single state administrative agency charged with the development, use, and control of all water resources in the state; [2] vest administrative and legal responsibility for pollution control in the new agency; and [3] establish a new system of water rights, freezing existing rights to surface water being used beneficially at the time of enactment and setting up a permit system for all other surface water use, as well as all ground water use.

One of the factors contributing to the water problem in the East is, of course, the growth of irrigation. According to T. H. Quackenbush, an irrigation engineer with the US Soil Conservation Service, the period 1949–56 witnessed an increase of 55 per cent in irrigated acreage in the 31 eastern states, with the present total estimated to exceed 3,000,000 acres. This trend, he stated, was spurred by several severe drought years but presumably will continue because farming practices and market conditions have so changed that many farmers can no longer afford the risks associated with unfavorable rainfall distribution in any year. For some crops, production costs have risen to such an extent that further investment in irrigation to insure maximum production every year is warranted. A collateral development to be expected is an increase in the number of large projects for irrigation water storage, which up to now has chiefly been limited to the construction of reservoirs by individual farmers.

Fred G. Gordon, assistant chief engineer, Dept. of Public Works, Chicago, presented a paper describing that city's Central District Filtration Plant, now under construction. The plant will have a capacity of 0.96 bgd at a filtration rate of 2 gpm/sq ft, but the design will permit operation at 3 gpm/sq ft, equivalent to a capacity of 1.68 bgd.

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Rat poison, the favorite name of the antifluoridationists for the chemical which is now being added to the water supplies of well over 30,000,000 people in the US, has reared its ugly connotations again. This time the dupe is none other than Ike himself and the rat poison the most effective yet found —Warfarin sodium. It is the fact that Warfarin is an effective blood anticoagulant as well as a powerful rat poison that led the President's physicians to administer it to him shortly after his heart attack in September 1955 and to continue his treatment with it since that time. Meanwhile, the only real news of that other rat poison is that the AMA, acting on a favorable report of its council on Foods and Nutrition and its Council on Drugs, has reaffirmed its support of fluoridation (January JOURNAL AW WA, p. 28 text). In New York, which put off its decision on the subject pending the AMA's reconsideration and is now ready to raise the issue again, there has, of course, been considerable opinionation on the subject, with Dr. Jonathan Forman of Columbus, Ohio, Dr. F. B. Exner of Seattle, Wash., and Dr. A. Allen London of Boonton, N.J., the leaders of the opposition, ready again to conduct warfare in the metropolis.

Fred C. Hagen, Fargo, N.D., water commissioner for 17 years, was honored at a luncheon arranged by the Chamber of Commerce in appreciation of his outstanding service to the city.

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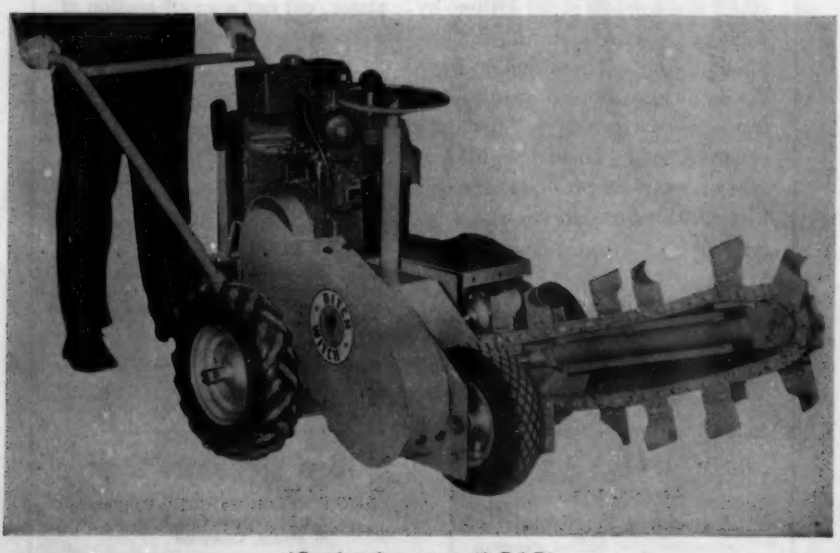
J. L. Schneider has taken up his duties as secretary of the Portland Cement Assn., Chicago. He had been assistant secretary since 1952 and served as manager of the Publications Bureau from 1954 to 1957.

A mad rush to Russian in the wake of Sputnik has been embarrassingly noticeable in the world of scientific literature. What has been most embarrassing, of course, is the need for what ASME has called "an attempt to correct the present situation in which the Russians are familiar with the content of most, if not all, of our technical publications, while only a few of theirs are translated for use by the English-speaking world." Under a $35,000 grant from the National Science Foundation, ASME will soon publish a translation of the bimonthly *Prikladnaya Matematika i Mekhanika,* leading Soviet publication on applied mathematics and mechanics. Meanwhile, for the chemical sciences, the Consultants Bureau, Inc., of New York publishes translations of nineteen Soviet journals. The prices of some of these works are such that we may be tempted to stick our heads back in the sand, but such headlines as that featuring the Soviet's Union's remarkable water resources development program, in which one project alone provides a capacity of 6,000,000 kw, "more than the total capacity of all the power plants at all the dams ever constructed by the Corps of Engineers," suggest that maybe even we have something to learn—about voda as well as vodka!

A self-propelled light trenching machine, the Model *C* "Ditch Witch," is being marketed by Charles Machine Works, Inc., 649 Birch St., Perry, Okla. Powered by a 7-hp air-cooled gasoline engine, the 34-in. wide unit can dig 3-, 4½-, or 6-in. trenches up to 2-ft depth at a speed of about 4 fpm. The factory price is $625. (See photo below.)

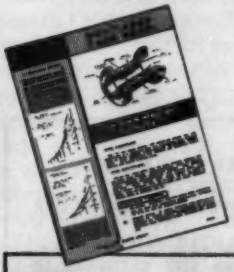


(Continued on page 68 P&R)

Low-Priced,
Performance-Proved Builders Dall Flow Tube
Cuts Differential Producer Head Loss 90%!

The Dall Flow Tube offers . . .

- **unsurpassed differential pressure recovery**
- **lower pumping and transmission costs**
- **lower initial, installation, and operating costs**
- **constant, stable discharge coefficient over wide flow range**
- **plastic-insert models available**



Keeping a head assures you of adequate line pressure at distant points . . . reduces pumping costs over extended periods. Numerous other advantages discussed in Technical Bulletin 115-L3C. Request your free copy today . . . and *keep ahead* in many ways! Write **Builders-Providence, Inc., 865 Harris Ave., Providence 1, Rhode Island.**

BUILDERS-PROVIDENCE
DIVISION OF
B-I-F INDUSTRIES BIF METERS FEEDERS CONTROLS

(Continued from page 66 P&R)

There's no fuel like an old fuel as far as Europe is concerned. Thus, it is in Norway and Germany that two notable efforts to reduce water pollution have been turned to the advantage of the erstwhile polluters. In Norway, Aktieselskapet Borregaard, the country's largest pulp and paper manufacturer, is spending $3,000,000 on a Zimmermann process steel reaction plant that will produce power through utilization of the plant's waste pulp liquor. Developed by engineers of Sterling Drug, Inc., New York, and built principally by A. O. Smith Co., Milwaukee, the plant is said to solve the economic and social problems associated with organic waste disposal, efficiently disposing of the waste and converting any fuel content of the waste into usable power—either process steam or electricity. Meanwhile, in Germany, Emscher Genossenschaft, an association of Ruhr district coal industry communities primarily formed to fight water pollution, is planning to process its waste water silt into dust coal (heat capacity, 4,000 kilocalories) and blast furnace coke. Although this will be a high-cost project, the reclamation process is aimed principally at cutting the present high cost of transporting and storing the 5,000,000 cu m of silt produced each year in district operations.

Less concerned with fueling, the US is still not completely ignoring its waste line. The Metropolitan Sanitary District of Greater Chicago is currently using the Zimmermann process to evaluate its efficiency in disposing of sewage sludge. And at least one coal producer, the Philadelphia & Reading Corp., is known to be actively pursuing silt reclamation by gasification.

Waste makes. . . .

Kenneth F. Tupper, president of Ewbank & Partners (Canada), engineering consultants, has been elected president of the Engineering Institute of Canada, taking office in May.

Harold Romer, director, Bureau of Sanitary Engineering, New York City Dept. of Health, has been commissioned sanitary engineering director (colonel) in the USPHS reserve.

Badger Meter Mfg. Co., Milwaukee, Wis., has purchased Counter & Control Corp., a Milwaukee manufacturer of controls for automation. The new acquisition will operate as a wholly owned subsidiary under the direction of its former president, Harold J. Geder.

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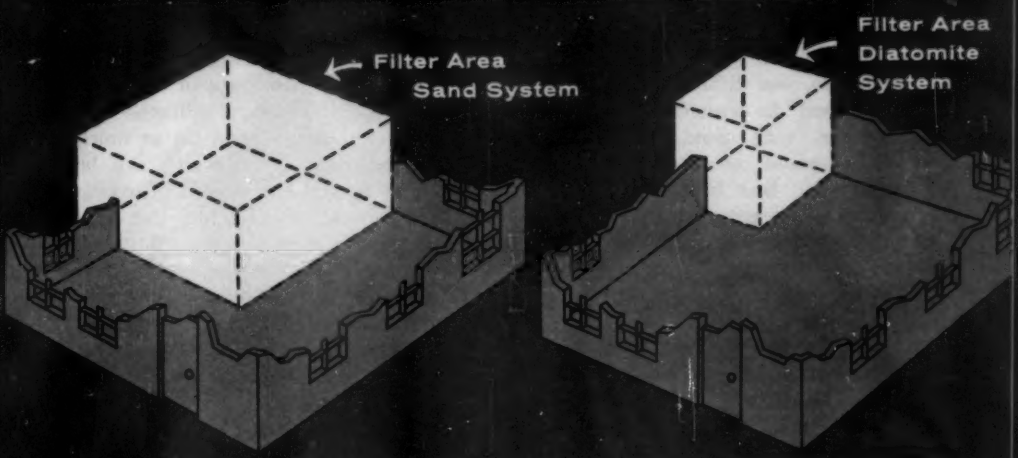
WITH CELITE DIATOMITE FILTRATION
YOU CAN GET CRYSTAL CLEAR WATER AND...



Cut space requirements as much as 75%

A Celite* diatomite filtration system requires only ¼ the housing space that a sand filtration system needs to deliver the same water capacity. Because of this, an actual Celite diatomite filter station was installed by Johns-Manville for only 55% of the cost of a comparable sand filter plant.†

For those communities that wish to increase their present water capacity but must hold down improvement costs, a Celite diatomite filter can in most cases be added right in the existing sand plant. Capacity can be more than doubled without spending a penny for additional land or construction.

Diatomite systems not only save space, but, under comparable conditions, they also improve water clarity. For with Celite, turbidity is usually lower, since more suspended impurities, including all floc, amoebae and algae, are removed. In fact in some cases, turbidity is so low it can't be measured.

Mined by Johns-Manville at the world's largest and purest commercial diatomite deposit, Celite is carefully processed for purity and uniformity. It is available in a wide range of grades to deliver the best practical balance of clarity and flow rate with any suitable filter. For further information see your nearby Celite engineer or write for free technical reprints and illustrated brochure to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Celite filter aids are composed of microscopic irregularly shaped particles like these. 90% of a given quantity of Celite is composed of countless channels and voids that trap the finest impurities while permitting the free passage of clear liquid.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products. †See *Comparison Studies of Diatomite and Sand Filtration* by G. R. Bell, Journal American Water Works Association, September, 1956 or write for free reprint.

Johns-Manville CELITE Filter Aids

(Continued from page 68 P&R)

The moon, on which, according to scientists, our first suburbs in space will "soon" be created, is going to confront us with some water problems which should convince even the most pessimistic that here on earth we're in heaven, if not the heavens. Unless the space stations along the way are a lot more frequent than so far suggested, extensions to this lunar subdivision are going to be at least economically unfeasible. And with no apparent local source of supply, we'd be inclined to consider the idea of lunar civilization just plain looney were it not for such spacialists as Dr. I. M. Levitt, astronomer director of the Fels Planetarium. Noting that, by the time we are ready to establish our first community on the moon, energy from fusion or from the sun will be both plentiful and cheap, Dr. Levitt has pointed out that some of the lunar rocks—the magnesium silicates—the white rocks, that is—contain as much as 13 per cent water, which can be extracted by crushing and then baking or electrolysis. It is his idea that such water will be used to satisfy not only the thirst of the Mensalites but their need to breathe as well, some of the supply being broken up into hydrogen and oxygen to provide an atmosphere within the plastic domes that will enclose all residential areas. Dr. Levitt's obvious appreciation of the primary importance of water as well as the ingenuity of his suggestion for obtaining it moves us to suggest that the first lunar suburb (or should that be superurb—or just supurb?) be named Levittown in his honor.

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Kimball Blanchard has joined the sales staff of Neptune Meter Co., New York. He was formerly associated with Ludlow Valve Co.; he was sales manager of the New York Branch of Rensselaer Valve Co., which Ludlow acquired in 1955.

The USPHS awarded 144 research grants totaling $2,000,000 during fiscal 1957 in support of studies in the field of sanitary engineering and occupational health. Of these grants, 82, totaling $760,000, were for research in water supply and water pollution control. Forty were for new projects and 42 for continued support of projects already under way. These grants include awards to investigators working in 46 institutions in 27 states and the District of Columbia. In addition, the Public Health Service inaugurated a research fellowship program in fiscal 1957 for advanced study in the broad field of sanitary engineering.

Water Service Labs., Inc., chemical engineers, has moved its New York offices to 615 W. 131st St., New York 27, N.Y.

John C. Brayton, former general manager, Utica (N.Y.) Board of Water Supply, died Feb. 18, 1958, at the age of 67. Born at Cortland, N.Y., in 1890, he attended Valparaiso Technical Institute in Indiana. In 1915 he became billing clerk for Utica's Consolidated Water Co., rising to vice-president by 1934. When the city took over the company in 1938, he became financial supervisor. In 1951 he was appointed general manager, a position he held until his retirement in 1956. Mr. Brayton was the Water Board's representative in AWWA.

Edward R. Tull, superintendent of the Rockingham, N.C., Water Dept. since 1932, died Feb. 12, 1958. He was 54. A member of AWWA since 1935, he received the Fuller Award in 1956 on nomination by the North Carolina Section. He was also a past-president of the North Carolina Water Works Operators Assn.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

WATER SUPERINTENDENT—Sierra Madre, Calif. (Pop. 8750), invites applications from men with 3 to 5 years of responsible supervisory experience in public or private water systems. 30 to 50 years of age. Salary range $500/$650 per month depending on qualifications. Position offers opportunities for advancement. Apply to City Administrator, City Hall, 55 West Sierra Madre Blvd., Sierra Madre, California. Telephone: ELgin 5–7135.

ASSISTANT WATER SUPERINTENDENT— Selection and salary on basis of education, character, training, and experience. Sanitary or civil engineering degree preferred. Age: 28 to 45. Salary: $457 to $575. Also position available for:

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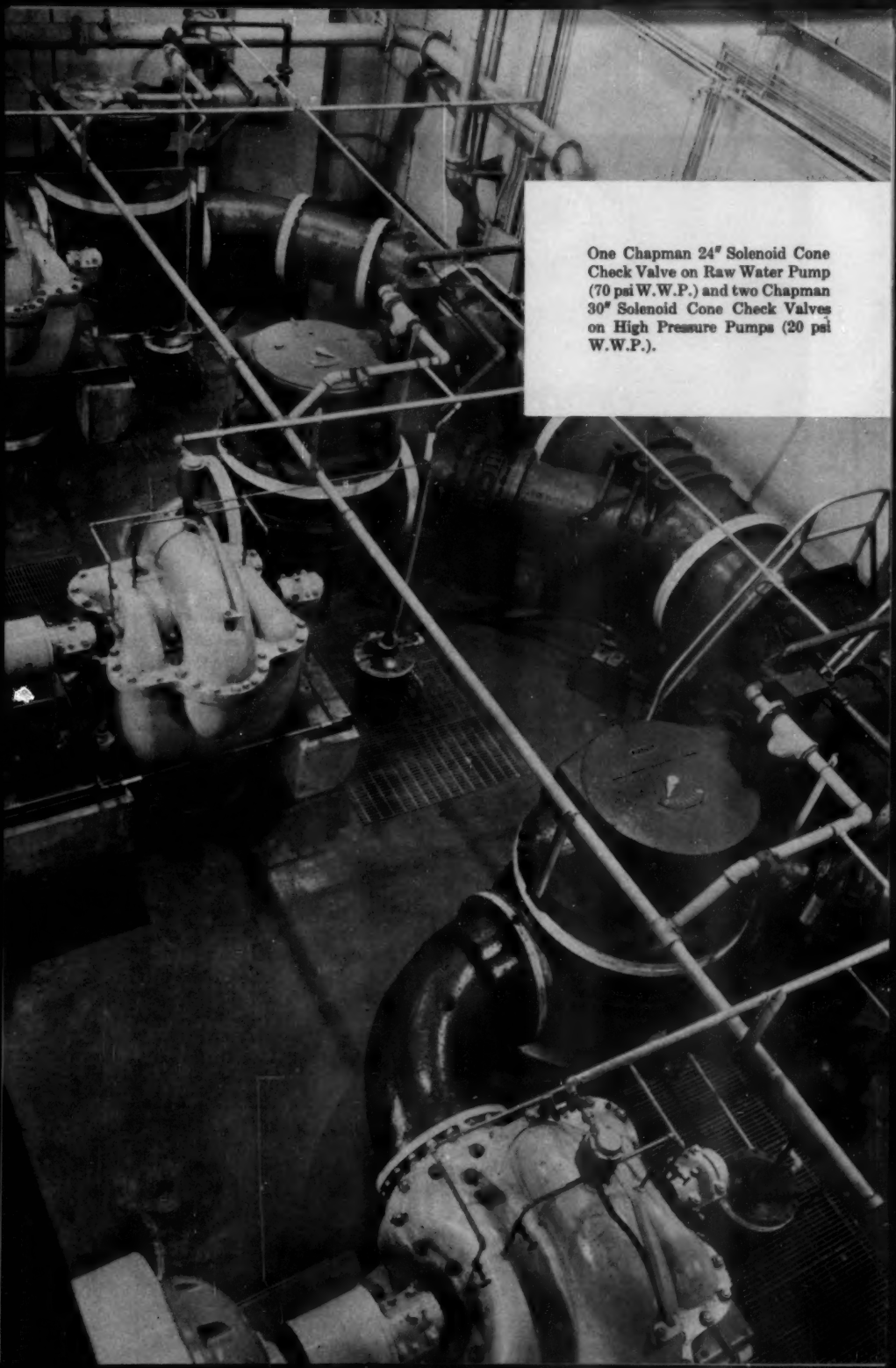

One Chapman 24" Solenoid Cone Check Valve on Raw Water Pump (70 psi W.W.P.) and two Chapman 30" Solenoid Cone Check Valves on High Pressure Pumps (20 psi W.W.P.).

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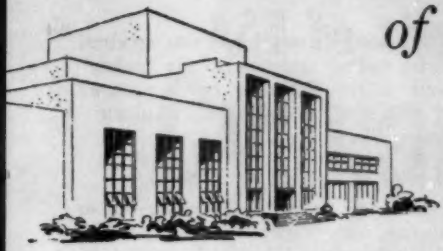

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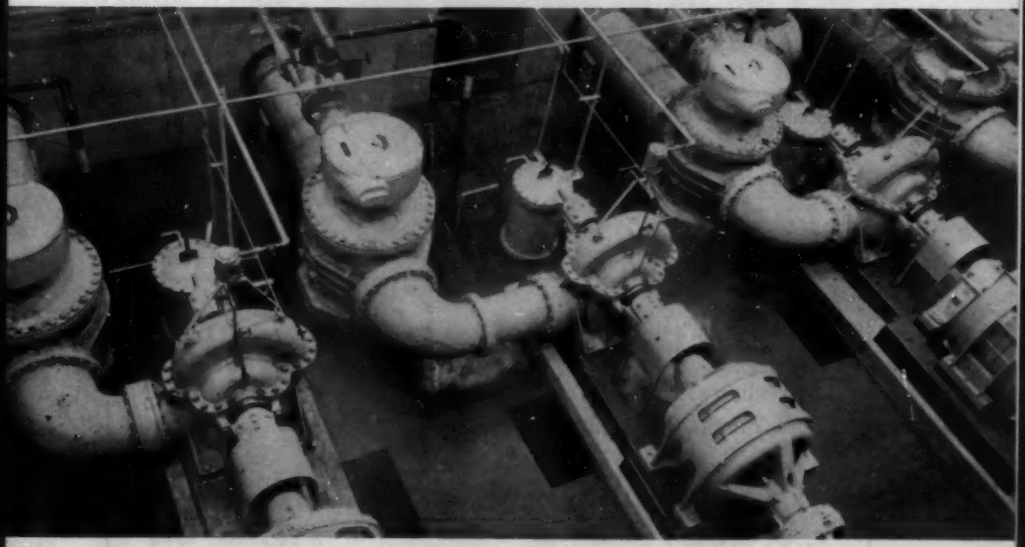


Three Chapman 24″ Solenoid Cone Check Valves on High Service Pumps (70 psi W.W.P.) and one Chapman 30″ Solenoid Cone Check Valve on Raw Water Pump (20 psi W.W.P.).

Correspondence

That Hover Cover

To the Editor:

The first thing that caught my eye in the February issue of the JOURNAL was the cover picture. Someone in Charlotte, N.C., evidently is not interested in a long life, for he is standing much too close to the pipe—and under the shovel bucket. That's more dangerous than Ike sitting in a carriage looking at the business end of a shotgun.

I personally have witnessed two cable failures involving heavy equipment. Fortunately no one was injured in either case. Nothing says it cannot happen even when a picture is being taken.

I imagine safety men will emit loud groans upon seeing this—especially those responsible for safety in the water works field, a group with a poor safety record according to recent surveys. This picture certainly can be used as a good example of how to keep from growing old.

ELROY F. SPITZER

New York, N.Y.
Feb. 25, 1958

* * *

How many letters have you received already, calling attention to the "safety" aspects of the February cover picture?

JAMES C. VAUGHN

Chicago, Ill.
Feb. 25, 1958

That safety is on the conscience of at least two water works men is good to see. In defense of Charlotte's water boss, Walter Franklin, and his two fearless friends, however, we point to the fact that Walter's arm's length proves that the trio is out from under. Meanwhile, we have apparently found the key to cover comment.—ED.

Super Is Sub

To the Editor:

As far as superintendent semantics is concerned, my thoughts coincide with those of Henry Wilkins Jr. (January P&R, p. 52) and your own (October 1957, p. 39 P&R). We are placed in the delicate position of blasting our own tuba or being left far below the standard of our fellows in the field of engineering and management. We should, at an early date, use collective efforts to improve the rating of our responsibilities.

X. D. MURDEN

Supt., Water Dept.
Portsmouth, Va.
Feb. 12, 1958

Amen, Manager Murden, amen! And may the improvement of the rating extend way beyond semantics!—ED.

Condensation

Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

BACTERIOLOGY

Identification of Coliform Bacteria Isolated From Water. Eijkman Test and Production of Indole at 44°C. IMViC Tests. R. Buttiaux; J. Samaille; & Y. Pierens. Ann. Inst. Pasteur (Fr.), 8:137 ('56). Authors studied 323 strains of *Escherichia coli* and found that 92.6% fermented lactose with production of gas in brilliant green bile medium and produced indole after 48 hr incubation at 44°C. None of 116 coliform organisms other than *E. coli* were capable of producing this result. They recommend this test, first described by Mackenzie, Taylor and Gilbert for recovery and enumeration of *E. coli* from water, but they consider it is necessary to extend incubation at 44°C for 48 hr. For methyl red and Voges Proskauer tests, authors recommend use of single tube of Fouad medium incubated at 30°C for 1–2 days. Fouad medium has following composition: glucose, 5 g; NaCl, 5 g; K_2HPO_4, 5 g; KH_2PO_4, 2 g; $(NH_4)H_2PO_4$, 2 g; $MgSO_4 \cdot 7H_2O$, 0.2 g; $MnSO_4 \cdot 4H_2O$, 0.02 g; $FeCl_3$, 0.005 g; and distilled water, 1,000 ml. For citrate utilization test, Simmons medium is used, incubated at 30°C. This temp. gives better results as has already been experience of other workers in this field. Urease test was carried out in Christensen medium incubated at 30°C. Under these conditions all *Klebsiella* and *Cloaca*, faecal and urinary strains, gave positive results. Further studies are being made to exam. suggestion that urease-positive strains from water indicate dangerous contamn. Again incubation at 30°C was found superior to 37°C.—*BH*

Systematic Study of Spore-forming Anaerobic Bacteria and Sulfite-Reducing Bacteria Isolated from 273 Samples of Drinking Water. H. Beerens; G. Muchemble; & J. Papavassiliou. Ann. Inst. Pasteur (Fr.), 8:150 ('56). Search for sulfite-reducing bacteria in 273 samples of water from wells showed variety of species of *Clostridium*. Authors found *Clostridium welchii* in 49.1% of samples and other species were found in 50.9%. Thus, *Cl. welchii* is not only organism in water that will produce black colonies, 5 mm or more in diam., after 24 hr incubation at 37°C. Suggestion by Willis that isolation of *Cl. welchii* is not good test for evidence of faecal contamination is discussed. It is necessary to define origin of species of *Clostridium* other than *Cl. welchii* found in water in order to interpret their epidemiological importance.—*BH*

The Problem of False Results ("Springer") in Water Examinations by the Coliform Titration Method. J. Lehmann. Z. ges. Hyg. u. Ihre Grenzgebiete (Berlin), 2:344 ('56). In detn. of "*Bacterium coli* titre" as used in Germany, presence of coliforms is investigated in tenfold water dilns. ranging from 100 cc to 0.01 cc. It has been found that in certain number of examns. test may be positive, for example, in 10 cc, but negative in greater vol. of 100 cc. These aberrant results, known as *springer* or *nieten*, were found to occur in 6.05% of 15,332 water examns. in work here described. These observations are generally and statistically discussed but no satisfactory explanation is forthcoming. It is considered that main cause of phenomenon must lie in complex variations in biochem. conditions existing in mixtures of water and nutrient medium and that these *springer* results must at present be regarded as due to chance. It is not likely that they can be eradicated by improvement in mechanical part of present titration technique.—*BH*

The Bacterial Genus *Klebsiella* in Water. Rev. Obras Sanit. Nacion (Arg.), 20:169 ('56). Presence of bacteria of genus *Kleb-*

(*Continued on page 88 P&R*)

(Continued from page 86 P&R)

siella was investigated in samples of water from River Plate and 113 strains were isolated and their biol. reactions studied. Serological typing carried out at Communicable Diseases Center, Chamblee, Ga., allowed classification of 103 of strains isolated into 28 distinct types. Presence of types 1 & 2 (Friendlander's *A* and *B*) as well as many other types often isolated from patients with various pathological conditions is noted. —*BH*

The Effect of the Aqueous Environment on the Ability of *E. coli* to Grow on a Selective Medium. The survival of *E. coli* in different types of water. Z. Buczowska. Roezniki Panstwowego Zakladu Hig. (Warsaw), 7:501 ('56). Expts. were carried out to study effect of different aq. environments on growth of *Escherichia coli* on lactose agar and sodium cholate media. Samples of distd. water, dil. sodium chloride solns., well water containing 210 mg of calcium carbonate per litre, sea water, and river water, were inoculated with 12-hr cultures of *Esch. coli* and plated at intervals on media. Plates from distd. water samples showed decrease in growth but growth on cholate medium could be restored by incubating sample in lactose, peptone and meat extract medium before plating. With sodium chloride solns. results varied and with well water counts were fairly constant for 6–7 days, then fell gradually. Rise occurred when 1.4% sodium chloride was added to water. Organisms inoculated in sea and river water samples died within 12–48 hr.—*WPA*

Experiments on the Antibacterial Properties of Algae. Arch. Hyg. u. Bakteriol. (Ger.), 140:597 ('56). Role of algae in self-purification of natural waters has been referred to in published work and author of present paper has previously described some expts. on antibacterial properties of mixed cultures of algae. The results of these experiments were to suggest that the antibact. property of algae is possibly due to 2 factors

(Continued on page 90 P&R)

(Continued from page 88 P&R)

—one a production of some antibiotic substance by algae and second factor which is associated with effect of light on metabolism of algae and increase in concn. of D.O. in exptl. medium. Present paper reports expts. made with pure culture of *Nitzschia palea*. Details are given of method of isolation of organism from pond water and its culture on inorg. medium contg. sodium silicate, sodium nitrate, and disodium hydrogen phosphate. Results of these expts. were: [1] antibacterial effect is greatest in cultures aged 4–8 days, [2] light and intensity of light play great part in this effect and increase concn. greatly, [3] effect was pronounced against *Bacterium coli, Proteus vulgaris*, and *Pseudomonas fluorescens* but not against other organisms tested, and [4] when suspensions of *Bact. coli* are filtered through film of algae produced by filtration of algal cultures through filter paper, number of living bacteria is reduced by about 50% but antibact. effect continues so that, after 24 hr standing, bacterial count in filtrate was nil. —*BH*

The Availability of Sulfur for *Clostridium perfringens* and an Examination of Hydrogen Sulfide Production. A.-R. Fuchs & G. J. Bonde. J. Gen. Microbiol., **16**:330 ('57). Utilization of several inorg. and org. sulfur compds. by 3 strains of *Clostridium perfringens* and production of hydrogen sulfide from these compds., were investigated. Sulfate, sulfite, thiosulfate, and sulfide cannot be used as source of sulfur, nor do they have any effect, when added in nontoxic concns., on growth of organisms in media contg. utilizable org. sulfur. Cystine or cysteine, which can be replaced by glutathione, were required by 3 strains tested; no addl. sulfur source was needed by 2 strains, but third also required methionine or homocyst(e)ine. Growing cultures produce hydrogen sulfide from sulfite, thiosulfate, cystine, cysteine, and glutathione, but not from methionine. Different enzyme systems are concerned with production of hydrogen sulfide from cystine and sulfite respectively. Sulfite-reducing capac. of some cultures was often reduced after several transfers in lab. media and reduction of sulfite then occurred only in presence of nicotinamide. Sulfite was reduced to sulfide by suspensions of resting organisms. Preliminary expts. suggest presence of hydrogenase system, organisms being able to activate molecular hydrogen for reduction of methylene blue and sulfite. Other hydrogen donors are utilized by organisms—in particular, glucose. Addn. of sulfites does not induce growth on substrates which do not support growth in sulfite-free media.—*WPA*

Rapid Detection of Coliform Organisms. A. J. Public Health. **46**:1405 ('56). This paper describes developments in technique described in previous paper for using 1-^{14}C lactose from which radioactive CO_2 is generated and detected after absorption on baryta water pad. In original method, 10 ml of 1-^{14}C lactose broth were used for each test and control. High cost necessitated marked reduction in quant. of medium. Sterile controls also generated some $^{14}CO_2$. This background evolution masked to some extent metabolic evolution of $^{14}CO_2$ making test less sensitive and increasing time necessary for test to reach significant level. Also much of $^{14}CO_2$ was dissolved in broth, which also increased time factor. Both of these factors

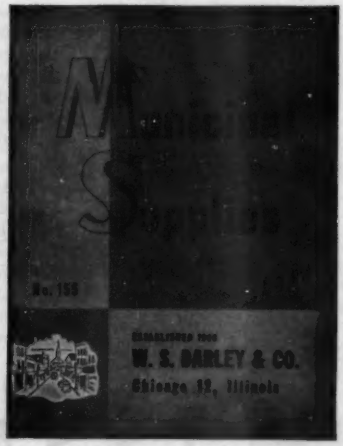
(Continued on page 92 P&R)

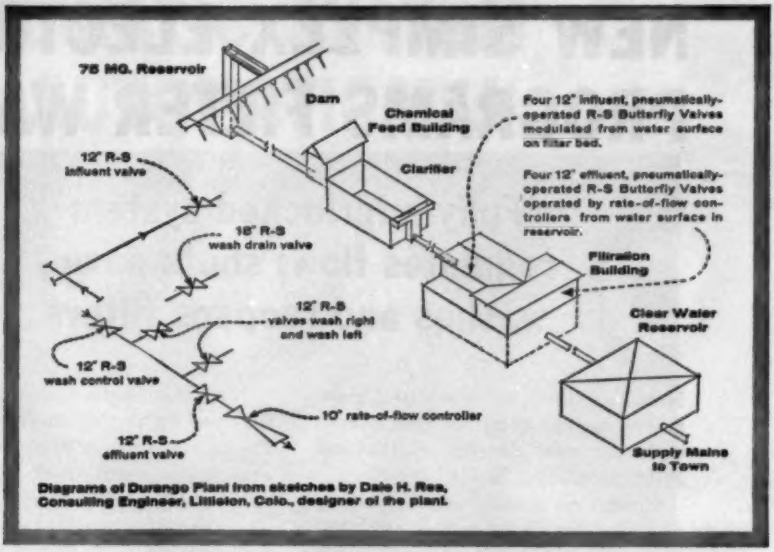
(Continued from page 90 P&R)

could be reduced by reducing quant. of broth. Method was, therefore, devised whereby water sample was filtered through membrane filter ½ in. in diam., which was then placed in 0.8 ml, later reduced to only 0.1 ml, of 1-^{14}C lactose broth contained in flat-bottom cup fitted to special app. so that air passed over it at rate of 3 bubbles per sec. and then over ½-in. absorbent pad saturated with baryta water, whole being immersed in 37°C water bath. After suitable time, pad was dried and its radioactivity counted for 5 min in Robinson gas flow counter. Advantage of latter was in its smaller counting chamber and consequently smaller background count. Examns. after 10 min in water bath indicated that as few as 5 cells could be detected in lag phase, but that when growth was in exponential phase, 4–5 hr were sometimes required for positive result. In lag phase, CO_2 evolution per cell was highest during first few min and was also higher for cells in low concn. than for cells in high concn. One hypothesis that could explain these anomalies was that reproducing cells conserve large quant. of CO_2 for use in building cellular material. Such retention should be preventable by incorporating certain poisons to prevent growth and reproduction but permit continuation of respiration for several hr. Preliminary tests with 2, 4 dinitrophenol showed considerably higher rates of $^{14}CO_2$ evolved in poisoned cultures than in controls. Lactose broth used contained 0.3% of 1-^{14}C lactose, specific activity of which was 3.01 μc/mg.—*BH*

Observations on the Anaerobes Present in a City Water Supply, With Special Reference to *Clostridium welchii*. A. T. Willis. J. Appl. Bacteriol., 20:53 ('57). Black colonies 3 mm or more in diam., which developed in Wilson & Blair's medium inoculated with samples of untreated water from city water supply, were examd. for their anaerobe content by isolation of pure cultures and by subculture in milk. It was shown that development of such colonies al-

(Continued on page 96 P&R)





Diagrams of Durango Plant from sketches by Dale H. Rea, Consulting Engineer, Littleton, Colo., designer of the plant.

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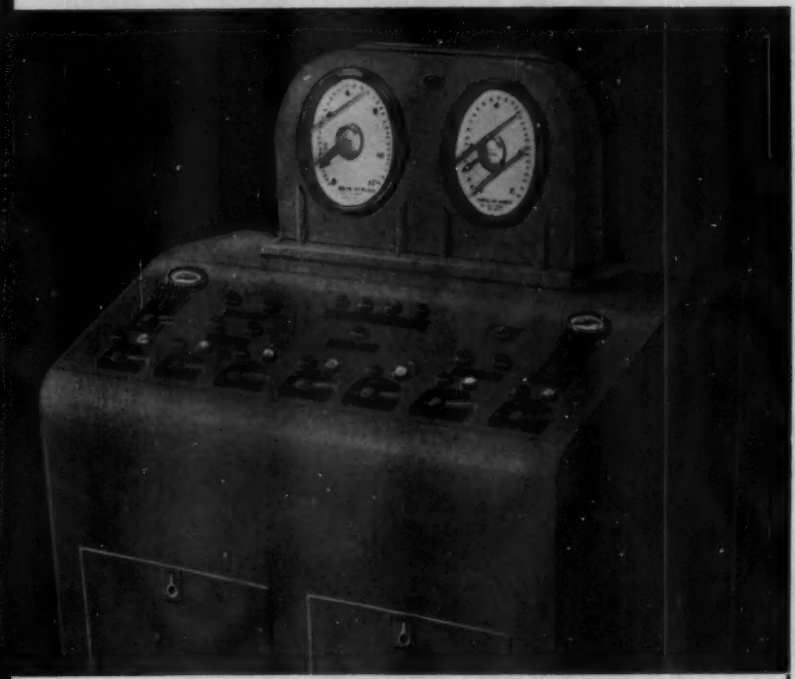

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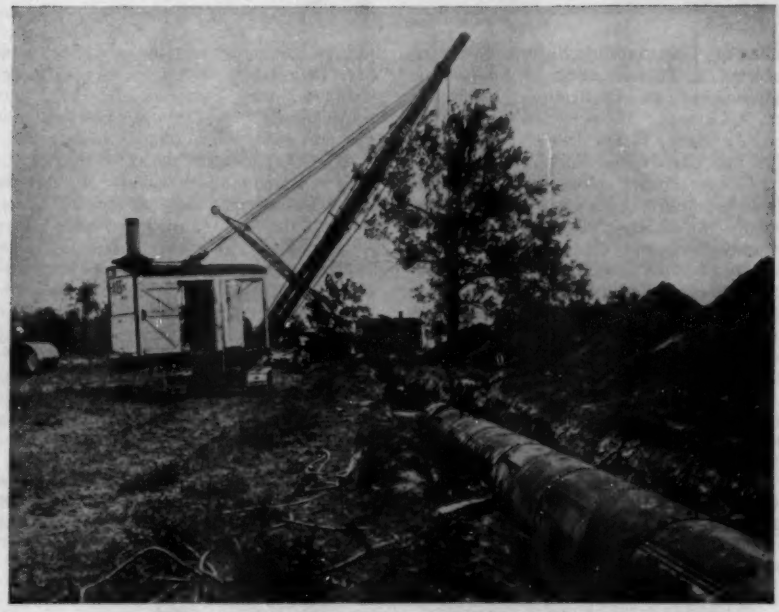
(Continued from page 92 P&R)

most always signifies presence of clostridia, usually *Cl. welchii*, and that subculture of such colony into milk gives reliable confirmation of presence of clostridia in general and of *Cl. welchii* in particular. 50 strains of *Cl. Welchii* isolated from water supply were examd., but none was found to be of heat-resistant food-poisoning variety described by Hobbs ET AL.—*PHEA*

Anaerobic Bacilli in a Treated Water Supply. A. T. WILLIS. J. Appl. Bacteriol., 20:61 ('57). Sand from filterbeds of city water supply was found to contain anaerobic bacilli and it is probable that these organisms are added to water as it passes through, because anaerobes are present in treated water. Emphasis is laid on value of anaerobe test on treated waters in assessing filter effi., and significance of bact. aftergrowth is pointed out.—*PHEA*

The Physiology of Iron Bacteria. G. HOHNI. Vom Wasser (Ger.), 22:176 ('55). Author gives acct. of work of many investigators on morphology and physiological properties of various iron bacteria and describes expts. made to detn. whether these bacteria could grow in presence of quants. of org. nutrient matter so small as to be analytically not detectable. Organisms tested were *Sphaerotilus natans* and *Leptothrix ochracea* (*Sphaerotilus natans*, forma *ochracea*). App. used for continuous supply of nutrient matter and methods used are described. It was found that both types were capable of growth in presence of quants. of nutrient matter too small to be detected by anal. methods. Presence of iron or manganese was not necessary. Content of sugars at which growth was observed varied between 0.02 and 0.07 mg/l. Appearance of these iron bacteria in nature can thus be ascribed to presence of utilizable org. matter in natural waters. Oxidation of ferrous oxide salts in water and in gelatinous sheath of Chlamydobacteria is exclusively due to oxygen in water; activity of cells is independent of this oxidation process.—*WPA*

(Continued on page 98 P&R)



Installing riveted steel pipe in 1925 near St. Louis' Stacy Park Reservoir.

Big steel mains still going strong in St. Louis

How long will large-diameter steel mains give satisfactory service? Let's look at an example in the city of St. Louis, where many miles of steel pipe have been installed.

Back in the mid-twenties the city developed a badly needed second source of water, at Howard Bend on the Missouri River. The project included installation of a 60-in. ID riveted steel main, nine miles from the filters to a new reservoir at Stacy Park, and eight miles farther to the city mains. This line was completed in 1926.

When more transmission capacity was required, the city installed thirteen miles of welded steel pipe, again mostly 60 in. ID. This pipe was coal-tar lined by the spinning method, and coated. It was supplied by Bethlehem Steel in 40-ft lengths, and joined in the field by mechanical couplings. Tests made in 1935 indicated the leakage to be less than a gallon per diameter-inch per mile of pipe in 24 hours.

After more than 30 years of continuous service for much of this pipe, and well over 20 years for the rest, the Water Department reports that it has given uniformly satisfactory service with every indication of continuing to serve well for many years to come.

Laying 40-ft lengths of 60-in.-ID pipe in St. Louis in 1934. Note the smooth, shiny coal-tar lining.

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BETHLEHEM STEEL

(*Continued from page 96 P&R*)

Studies on Thermophilic Sulfate-Reducing Bacteria. I. Identification of *Sporovibrio desulphuricans* as *Clostridium nigrificans*. L. L. CAMPBELL; H. A. FRANK; & E. R. HALL. J. Bact., **73**:516 ('57). Expts. have shown that *Clostridium nigrificans* is capable of reducing sulfate, sulfite, and thiosulfate to hydrogen sulfide. Presence of cytochrome pigments in *Desulphovibrio desulphuricans* was confirmed, and absence of these pigments in *Cl. nigrificans* and *Sporovibrio desulphuricans* was established. Morphological, cultural, immunological, and biochem. studies revealed that *Cls nigrificans* and *S. desulphuricans* are identical, and that they are distinctly different from *D. desulphuricans*. As name *Cl. nigrificans* has taxonomic priority, spore-forming thermophilic sulfate-reducing bacteria should be properly named *Clostridium nigrificans*.—*WPA*

Bacteriological Aspects of Katadyn Filtration in the Purifications of Water. M. G. MCENTEGART & D. PEDEN. J. Trop. Med. & Hyg., **60**:73 ('57). This is short acct. of number of bact. investigations which were undertaken to test efficacy of modern Katadyn filter. Latter consists of 2 parts, clarifying filter candle and silver-containing core of candle where oligodynamic action is exercised. It was shown that Katadyn filter removed *Salmonella enteritis* and *Salmonella thompson* from artificially infected water. Bacteria causing typhoid, paratyphoid, and cholera were not tested. *Staphylococcus aureus* and *Streptococcus faecalis*, which were shown by means of modified Rideal-Walker technique to be relatively resistant to silver, were not removed by Katadyn filter. It is, however, considered that with certain reservations filter may be said to provide convenient means whereby "potable water may be obtained from contaminated source."—*BH*

The Use of Membrane Filters in the Bacteriological Examination of Water and Air. M. A. GOHAR & A. A. EISSA. Z. Hyg. Infektionskrankh., **143**:364 ('57). Authors give acct. of work which was carried out to

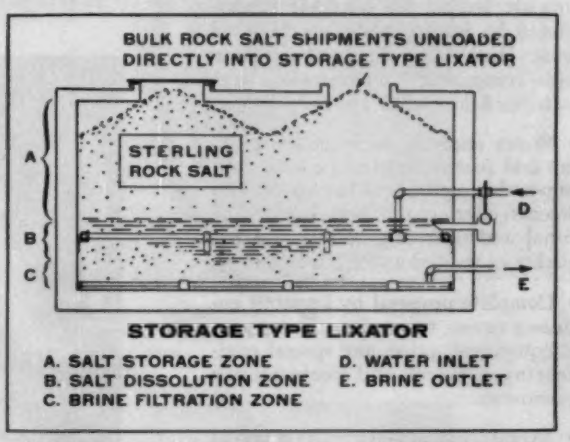
(*Continued on page 102 P&R*)

Getting top performance from your water-softening equipment?

An important requirement for efficient water-softener performance is the correct use of brine for regeneration. This article, #14 in a series prepared by International Salt Company, discusses equipment that can produce crystal-clear, fully saturated brine from rock salt. This brine, in turn, aids in effective regeneration.

Producing crystal-clear brine at lowest cost—by self-filtration.

Today, more and more soft-water installations are using a foolproof brine-making process that produces crystal-clear brine from rock salt, without using supplemental filter beds or other filtering devices. This process takes place in the "Sterling Lixator," a rock-salt dissolver developed exclusively by International Salt Company. The resulting Lixate Brine is brilliantly clean and clear . . . does an excellent job of regenerating zeolite and/or base-exchange resins.



The Storage Lixator is a combination storage and dissolving tank that makes Lixate Brine automatically from rock salt. Many other types of Lixators are available for specific needs.

Here, briefly, is how self-filtration works in the Sterling Lixator: A Lixator is filled with Sterling Rock Salt. Water, admitted near the top of the dissolving tank, dissolves salt as it flows downward. While flowing down, the brine made in this way becomes fully saturated, and can absorb no more salt. Still flowing down, this brine is *completely filtered* by the salt-crystal bed in the bottom portion of the Lixator. Thus, the Lixate Brine drawn off through a discharge pipe at the bottom of the Lixator is clean, pure, and crystal-clear.

Other Lixator advantages. 1. The Lixator permits salt storage and brine making at one location most convenient to the point of salt entry. *Pipes* deliver brine to points of use. 2. This piping feature eliminates the work of moving dry salt from storage piles to other plant locations. It permits substantial savings in labor. 3. The Lixator *automatically* controls salt feed, water feed, and brine discharge.

For expert advice on the particular Lixator type that will do the best job for you, phone or write the nearest district office, or write direct to International Salt Company, Inc., Scranton 2, Pa.

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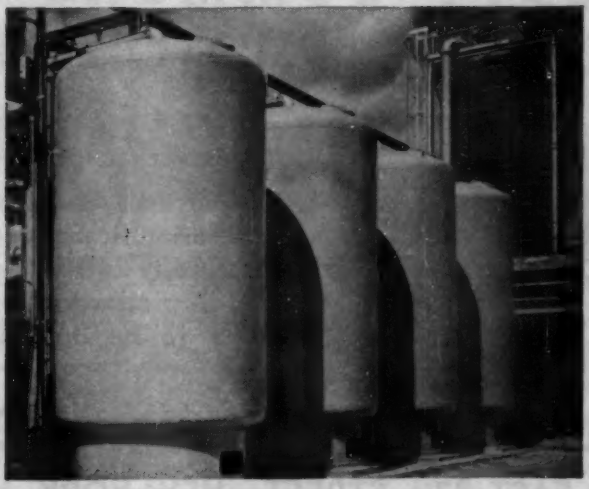


EQUIPMENT. Permutit supplies complete equipment. Critical parts such as valves, chemical feeders and controls are designed and made by Permutit.

(*Continued from page 98 P&R*)

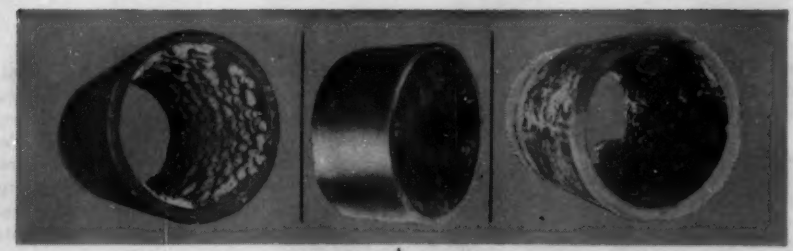
compare older methods of bact. examn. of water with new membrane filter method. Results, given in tables, of presumptive *coli* test, direct plate count and membrane filter test, show that direct plate count gives highest figures, which are also believed to be nearest to exact number of organisms present. In case of clean or moderately pold. water all 3 methods give similar counts. Membrane filter, which is speediest method, is therefore recommended only for testing clean water—for example, tap or deep-well water—and direct plate count is recommended for examn. of pold. water—for example, river water or shallow-well water. Authors also tested use of membrane filter for bact. examn. of air with much success, although modifications of filters are suggested.—*WPA*

BOILERS AND FEEDWATER

A Simple Procedure for the Internal Control of Silica in Boiler Waters. G. V. L. N. Murty & U. A. Roa. Eng. and Boiler House Rev., 72:15 ('57). To control deposition of silica scale in boilers, regular comparison should be made between ratio of silica in boiler water to silica in feed water and ratio of chloride in boiler water to chloride in feed water. When silica ratio is less than chloride ratio, silica scale has probably been deposited. Modifications of molybdenum blue method for detn. of silica are suggested to make it suitable for routine anal.—*WPA*

Water Conditions for High-Pressure Boilers. D. E. Voyles & E. C. Fiss. Corrosion, 13:589 ('57). Experience of Duke Power Co. has been that high-pressure boilers can be operated satisfactorily for extended periods with demineralized or condensate makeup, provided that care is taken to keep O concn. of boiler water low at all times by maintaining an adequate hydrazine residual. Chem. cleaning will be required at about 5-hr intervals. After 3 yrs. of operation turbines showed only small amt. of material deposited on blading at about satn.

(*Continued on page 104 P&R*)



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(Continued from page 102 P&R)

point. This material is mainly silica and contains some magnetic iron dioxide. Condensate pH is consistently about 8.5.—*CA*

Localized Corrosion in Steam Boilers. R. N. PARKINS. Corrosion Technol. (London), 2:43 ('55). Pitting in boilers can be result of O attack or of high salt concns. Both conditions can be controlled by proper water treatment.—*CA*

Deionization of Boiler Feed Water. J. THOMPSON. Tech. Assoc. Pulp Paper Ind., 39:42A ('56). Trend in paper industry towards use of higher pressure boilers necessitates boiler feed water of very high qual., with very low concn. of residual silica. Author discusses advantages and present status of mixed-bed ion exchange for deionization of water, stresses need for preliminary treatment of water to avoid org. fouling of resins, and describes briefly some specific examples of use of mixed-bed units. —*WPA*

Locomotive Feed Water Treatment. Ry. Gaz. (London), 104:373 ('56). Individual locomotive int. treatments of boiler feed water are described. These include Afloc self-contained chem. tank and pump, which injects appropriate chem. treatment directly into boiler in proportion to water evapd. Compressed chem. briquettes, incorporating antiform chems., are used, which slowly dissolve in tender water. This method extends period between boiler washouts, and economizes in steam consumption, thus saving on fuel consumption and boiler maintenance.—*WPA*

Boiler Water Treatment: A Formula for the Control of Sludge and Scale in Internal (Carbonate) Treatment. J. A. GRAY. J. Inst. Fuel (London), 30:577 ('57). Empirical study has shown that in int. treatment of low-pressure boilers successful sludge and scale control can be achieved by observing only 2 conditions: [1] Mg hardness of feed must be kept above certain min. level, which is related only to Ca hardness and SiO_2 content of feed. The formula index (X_F) in the expression $X_F = (100/CaH)[(MgH/3) - SiO_2]$ should be greater than 7, where CaH and MgH represent Ca and Mg hardness, resp. (expressed as $CaCO_3$) and SiO_2 is the silica content. X_F is a convenient, dimensionless quant., but hardness concns. are usually expressed in ppm. [2] Total carbonate alky. in boiler should be between 200 and 300 ppm (expressed as $CaCO_3$), with 300 the preferred figure (i.e., sufficient to restrict total hardness in boiler water to 5 ppm). This method was tested by survey of operating data on 101 boilers with internal conditions classified as excellent or poor, and by prolonged expts. at 15 other boiler plants operated at pressures up to 200 lb/sq in. No exceptions have yet been found and method is independent of type of boiler and raw-water supply.—*CA*

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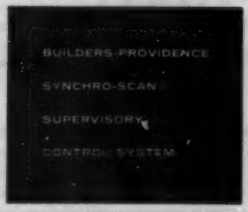

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Service Lines

A photoelectric colorimeter, with a recently developed titration adapter, is described in a 14-page bulletin issued by Photovolt Corp. This equipment, known as Lumetron Colorimetric Titrator Model 401-T, is said to be the first of its type for rendering color and turbidity titrations independent of individual judgment. Information may be obtained by writing for Bulletin 355, to the Photovolt Corp., 95 Madison Ave., New York 16, N.Y.

An electronic recorder that can receive and record output from up to four remote "Ring Balance" meter-operated slide wires simultaneously is described in a 4-page bulletin, MSP-149, obtainable from the manufacturer, Hagan Chemical & Controls, Inc., Dept. 627, Hagan Bldg., Pittsburgh 30, Pa.

Steel tanks and reservoirs, as well as pipe installations, are pictured in a 16-page illustrated brochure, in color, available from the Darby Corp., Kansas City 15, Kan.

New controlled-volume pumps, their design, features, and applications, are described in two bulletins, each 2 pages in length and printed in two colors. Bulletin No. 1157 describes a diaphragm metering pump; No. 1257, the new industrial "miniPump." Both are available from the Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Sodium and potassium silicates are featured in a 16-page folder, which describes the physical and chemical properties, applications, and advantages of these

(*Continued on page 108 P&R*)

Service Lines

(*Continued from page 106 P&R*)

chemicals. Copies may be obtained by writing the Philadelphia Quartz Co., 1158 Public Ledger Bldg., Philadelphia 6, Pa.

A single-gasket cast-iron pipe joint, known as "Fastite," is now being produced by American Cast Iron Pipe Co., Birmingham 2, Ala. Features of the new joint include a double-sealing rubber gasket. Information about this product is contained in an illustrated 12-page booklet, issued by the manufacturer.

Advantages of steel pipe, particularly its carrying capacity, are described in an 8-page, two-color, illustrated booklet, published by the Steel Plate Fabricators Assn., 105 W. Madison St., Chicago 2, Ill.

Caterpillar Tractor Co. has issued a new full-color, 24-page "Maintenance Guide" for its D2, D4, and D6 tractors. Complete information on operation and servicing of these machines is contained in the booklet, available by requesting Form DE768 from the company's advertising division at Peoria, Ill.

Activated-carbon characteristics and uses are the subject of a 12-page booklet, "Powdered Activated Nuchar for Purification and Reclamation," copies of which may be obtained from the Industrial Chemical Sales Div., West Virginia Pulp & Paper Co., 230 Park Ave., New York 17, N.Y.

Portable thickness gages for pipe walls are described, with drawings and photographs, in a new bulletin, No. N.I. 157, which may be obtained by writing the Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio.

A flow controller, Type "S," that is said to be capable of maintaining a uniform rate of filtration with high accuracy is offered by the Simplex Valve & Meter Co. This regulating device is the subject

(*Continued on page 110 P&R*)

Service Lines

(Continued from page 108 P&R)

of a comprehensive 12-page bulletin, No. 900, which is available by writing the manufacturer at 7 E. Orange St., Lancaster, Pa.

Asbestos-cement pipe, with "Fluid-Tite" couplings, is the subject of a 4-page pamphlet issued by the Keasbey & Mattison Co., Ambler, Pa.

Membrane filters and related apparatus are described in detail in an illustrated technical brochure (16 pages) available from the Millipore Filter Corp., Watertown 72, Mass.

A self-contained slurry feeder has been introduced by Wallace & Tiernan Inc. This packaged unit, which eliminates the necessity of installing a number of individual elements, is the subject of a technical bulletin (8 pages), which may be obtained by writing to the manufacturer at 25 Main St., Belleville, N.J., and asking for publication No. TP-10-M.

Sodium base-exchange water softeners are the subject of Bulletin 28B7107A, which has been issued by the manufacturer, Allis-Chalmers Manufacturing Co., Milwaukee 1, Wis.

Prefabricated underground pumping stations, developed for simple installation and automatic operation, are discussed in an 8-page bulletin. Diagrams and photographs are combined with text to describe in detail the Z-F Station. The booklet is available from the manufacturer, Zimmer & Franceson, P. O. Box 359, Moline, Ill.

Time-impulse telemetering applications are the subject of an 8-page bulletin (No. 230-P4), which includes photographs, schematic diagrams, and performance charts for "Chronoflo" equipment. Copies may be obtained from Builders-Providence, Inc., Div. of B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R.I.

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Abbott, Joseph A., Comr., Passaic Valley Water Com., 1525 Main Ave., Clifton, N.J. (Jan. '58)

Adams, John Tennant, Mgr., Water Div., Water, Gas & Sewage Treament Dept., 414 W. 1st St., Duluth 2, Minn. (Jan. '58) *M*

Allender, Robert C., Asst. Mgr., Peoria Water Works Co., 129 S. Monroe, Peoria, Ill. (Jan. '58) *M*

Allison, Gus Benjamin, Jr., Sales Repr., Southern States Chem. Co., Box B, Branwood Station, Greenville, S.C. (Jan. '58) *P*

Anderson, Arvid H., Supt. of Water, Bessemer Township, Ramsay, Mich. (Jan. '58)

Armstrong, H. G., Supt., Water Dept., Nickerson, Kan. (Jan. '58) *MRD*

Armstrong, Robert L., Western Sales Mgr., Henry Pratt Co., 3445 W. 8th St., Los Angeles 5, Calif. (Jan. '58)

Ball, William J., Sales Mgr., Water Pipe & Supply Co., Inc., Voorheesville, N.Y. (Jan. '58)

Batchelder, John Edwin, Product Sales Mgr., International Minerals & Chem. Corp., 20 N. Wacker Dr., Chicago 6, Ill. (Jan. '58) *P*

Beyer, Walter, Supt., Water & Sewage Depts., Neillsville Utilities Com., 118 W. 5th St., Neillsville, Wis. (Jan. '58) *MP*

Bianucci, T. John, Gas Div. Supt., Pacific Gas & Electric Co., Box 930, Stockton, Calif. (Jan. '58) *D*

Bielman, Kenneth D., Civ. Engr., Cornell, Howland, Hayes & Merryfield, 1600 Western Ave., Corvallis, Ore. (Jan. '58) *RD*

Bloomfield, William W., Sales Repr., Wallace & Tiernan, Inc., Belleville, N.J. (Jan. '58)

Boyd, John W., Asst. Supt., Water Dept., Eureka Springs, Ark. (Jan. '58) *M*

Brelje, Walter Edwin, Chief Engr., Frank B. Sarles, 425 S. E St., Santa Rosa, Calif. (Jan. '58) *RPD*

Breneman, W. M., Supt. of Water Treatment & Sewage Disposal, Box 3466, Odessa, Tex. (Jan. '58)

Brent, Harold O., Asst. Supt., City Utilities, Alton, Kan. (Jan. '58) *MRPD*

Brown, Howard B., Development Engr., Central Fibre Products Co., Quincy, Ill. (Jan. '58) *P*

Bryant, W. C., Pres., Visi-Meter, Inc., 301 N. 17th St., Kansas City 2, Kan. (Jan. '58) *D*

Burnett, Carey C., 1650 Maryland Ave., Albany, Ga. (Apr. '56)

Burtner, Calvin R., Supt., Water Works, 4450 McCoy St., Lawrence, Ind. (Jan. 58)

Caho, Paul G., Sales Office Mgr., Mueller Co., 2801 E. 12th St., Los Angeles, Calif. (Jan. '58) *D*

Carbaugh, H. Clark, Research Asst., Dept. of San. Eng. & Water Resources, The Johns-Hopkins Univ., Baltimore 18, Md. (Jr. M. Jan. '58)

Case, Howard L., Supt., Water & Light Dept., 156 Chestnut St., Meadville, Pa. (Jan. '58) *MRPD*

Chandler, J. S., Jr., Drafting Supervisor, Colorado Interstate Gas Co., Box 1087, Colorado Springs, Colo. (Jan. '58) *D*

Chung, Myung Sik, Grad. Student, Univ. of Minn., 630—11th Ave., S.E., Minneapolis, Minn. (Jr. M. Jan. '58)

Clanton, C. N., Chief Engr., State Inspection Bureau, 625 Polk, Topeka, Kan. (Jan. '58) *RD*

Clinger, Charles Burke, Vice-Pres., Gifford-Hill-American, Inc., Box 4335, Station A., Dallas, Tex. (Jan. '58) *M*

Cocker, Norman T., Water & Sanitation Services Supervisor, Dept. of National Defence, 318 Algonquin Dr., RCAF Station, Centralia, Ont. (Jan. '58)

Cohen, Jesse M., Chemist, Robert A. Taft San. Eng. Center, 4676 Columbia Parkway, Cincinnati 26, Ohio (Jan. '58) *P*

Connolly, William M., Water Chem. Eng., South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago, Ill. (Jan. '58) *P*

Cook, Albert Holt, Field Supervisor, Distr. Div., Water Works, 2861 Municipal St., Dallas, Tex. (Jan. '58) *D*

Cook, Russell T., Civ. Engr., Water Dept., 6731 Lake Fair Circle, Dallas 14, Tex. (Jan. '58) *M*

Cooper, Harry Frederic, Assoc. Civ. Engr., Water Dept., Balboa Park, San Diego, Calif. (Jan. '58) *M*

Cooper, M. D., 1529 Stovall St., Augusta, Ga. (Apr. '33)

Courter, J. T.; *see* Sand Spring (Okla.) Munic. Water Bd.

Cox, Knollin Bucher, Supt. of Utilities, Borough of Wenonah, Wenonah, N.J. (Jan. '58) *MPD*

Craigmile, Joseph D., Civ. Engr., Ayres, Lewis, Norris & May, Ann Arbor, Mich. (Jan. '58) *MRPD*

Crawford, Robert E., Plant Design Engr., Wilson & Co., Box 28, Salina, Kan. (Jan. '58) *P*

Crossley, Eugene I., Chemist, Water Dept., 6100 Colorado Blvd., LaMesa, Calif. (Jan. '58) *PD*

Cumber, Leslie W., Design Engr., Water Works, 301 Munic. Bldg., Dallas, Tex. (Jan. '58) *PD*

Curnow, William A.; *see* Stroudsburg (Pa.) Munic. Authority

Dallas Water Works, W. S. Mogle, Design Engr., 2015 Commerce St., Dallas, Tex. (Munic. Sv. Sub. Jan. '58) *MRPD*

Danford, Dan, Gen. Mgr., California Michigan Land & Water Co., 269 S. Rosemead, Pasadena, Calif. (Jan. '58) *M*

Denton, Thomas E., Water Supt., Yates Center, Kan. (Jan. '58) *MRPD*

DeJong, Tim, USOM—Iran, APO 205, New York, N.Y. (Apr. '58)

D'Ellz, Robert Allen, Mgr., Garratt Eng. & Equipment Co., 30 Rollins Rd., Hillbrae, Calif. (Jan. '58) *P*

DeNooyer, Marinus, Comr., Passaic Valley Water Com., 1525 Main Ave., Clifton, N.J. (Jan. '58)

Dickson, D. B., Plant Supervisor, N. Texas Munic. Water Dist., Box 248, Wylie, Tex. (Apr. '58)

Diekstein, Irwin L., City Chemist, 1605 N. Dunn St., Bloomington, Ind. (Jan. '58)

Docal H., Antonio T., Civ. Engr., Calle 27, No. 902, Vedado, Havana, Cuba (Jul. '58)

Dozier, William R., Supt., Selma Water Co., Selma, Ala. (Jan. '58) *MRPD*

Drisko, John B., Assoc., Tippetts, Abbott, McCarthy, Stratton, 29 Hickory Dr., Maplewood, N.J. (Jan. '58) *R*

Egan, Tom J., Sales Repr., James B. Clow & Sons, Inc., Box 6600-A, Chicago, Ill. (Jan. '58)

Elwood, John Robert, San. Engr., State Bd. of Health, Box 210, Jacksonville, Fla. (Jan. '58) *MRP*

Engle, Robert M., Office Cashier, Richmond Water Works Corp., 14 N. 10th St., Richmond, Ind. (Jan. '58) *M*

Ewing, William Curtis, Plant Engr., Purification Dept., Indianapolis Water Co., 1220 Speedway Ave., Indianapolis 7, Ind. (Jan. '58) *P*

Farnham, Willard, Sales Engr., Farnham Chem. Co., 4244 N.E. Alberta St., Portland 13, Ore. (Jan. '58) *P*

Finkbeiner, Albert D., Oil & Gas Sales, Tidewater Oil Co., Shafter, Calif. (Jan. '58) *D*

Fisher, Sallie Ann, Chemist, Rohm & Haas Co., 5000 Richmond St., Philadelphia, Pa. (Jan. '58) *P*

Forsythe, W. J.; *see* Victoria (B.C.) Dept. of Recreation & Conservation

Fuller, Andrew J., Regional Director, Public Health Eng., State Dept. of Health, 119 E. Main St., Rochester 4, N.Y. (Jan. '58) *P*

Gabrovich, Frank, Foreman, Water Dept., 1930 Prairie, Glenview, Ill. (Jan. '58) *MRP*

(Continued on page 116 P&R)

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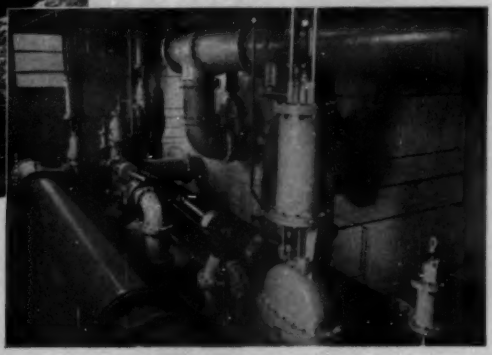

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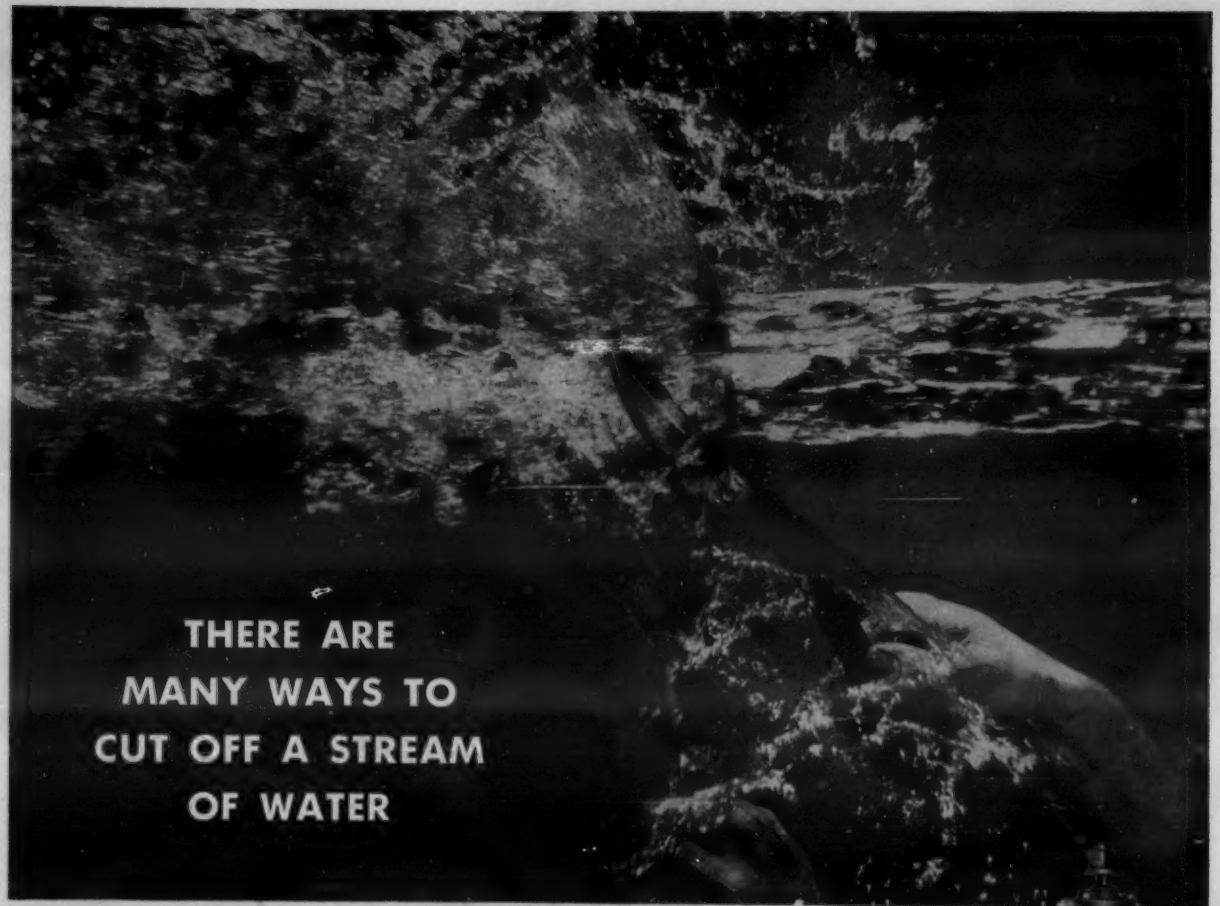

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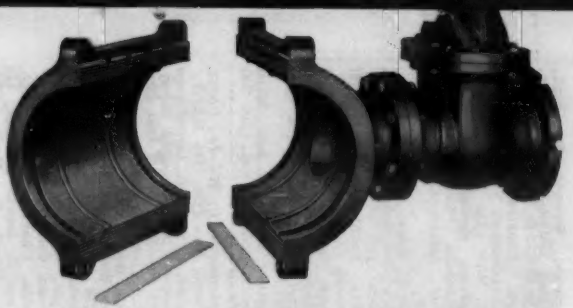

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(*Continued from page 112 P&R*)

Gesley, Howard Robert, Asst. City Engr., 11391 Acacia St., Garden Grove, Calif. (Jan. '58) *MD*

Gingher, Darrow B., Assoc. Mech. Engr., Dept. of Water & Power, 410 Ducommun St., Los Angeles 12, Calif. (Jan. '58) *D*

Glass, Leonard M., Asst. Project Engr., Whitman, Requardt & Assocs., 1304 St. Paul St., Baltimore 2, Md. (Jan. '58) *RPD*

Goedert, Paul, Chief, Hydrologic Office of the Kivu State of the Govt. of the Belgian Congo, Box 485, Bukavu, Belgian Congo (Jan. '58) *MRPD*

Goldfrank, Herbert John, Mgr. of Jaguar Dept., Stein, Hall & Co., Inc., 285 Madison Ave., New York, N.Y. (Jan. '58) *P*

Gray, William P., Chemist, Lansdale Tube Co., Div. of Philco Corp., Church Rd., Lansdale, Pa. (Jan. '58) *RP*

Gregory, Monroe Meade, Jr., Sales Engr., M. R. Mills, Jr., 2910 W. Clay St., Richmond 21, Va. (Jan. '58)

Gryka, Walter J., Supt. of Water, Rockford, Mich. (Jan. '58)

Grider, Clyde H., Prod. Supt., City Hall, Napa, Calif. (Jan. '58) *RP*

Gunther, Frederick J., Public Works Div., Waukesha Motor Co., Waukesha, Wis. (Jan. '58) *P*

Hall, J. Martin, Chief Engr., Wilson & Co., Box 28, Salina, Kan. (Jan. '58) *R*

Haipenny, Leonard C., Pres., Water Development Corp., 3938 Santa Barbara Ave., Tucson, Ariz. (Jan. '58) *R*

Hamlet, L. E.; *see* Tuscumbia (Ala.) Water Dept.

Hamman, Everett Ray, Maintenance Supervisor, Dept. of Public Property, 1085 S. Main St., Decatur, Ill. (Jan. '58) *M*

Hancock, Austin P., Administrator, Water Bd., San Antonio, Tex. (Jan. '58) *MR*

Handy, Charles R., Director of Public Works, 11391 Acacia St., Garden Grove, Calif. (Jan. '58) *MRD*

Hawes, Richard D., Results Engr., Metropolitan Utilities Dist., 18th & Harney, Omaha, Neb. (Jan. '58) *MPD*

Hawley, Edward, Sales Repr., James B. Clow & Sons, 606 Sherland Bldg., South Bend 1, Ind. (Jan. '58)

Hawley, G. H., Field Sales Mgr., Alladdin Labs., Inc., Box 992, Indianapolis, Ind. (Jan. '58) *P*

Herrman, John A., Director of Services, City Warehouse, Hays, Kan. (Jan. '58) *RD*

Hins, Louis A., City Supt., St. Francis, Kan. (Jan. '58) *MRD*

Hoffman, Elmer C., Supt. of Utilities, Moundridge, Kan. (Jan. '58) *MRD*

Hoxworth, Warren E., Partner, Hoxworth, Behnke & Girard Assocs., 213 Kings Highway, E., Haddonfield, N.J. (Jan. '58) *PD*

Hummelstown Water Supply Co., Jack P. Miller, Asst. Dist. Mgr., 3697 Derry St., Harrisburg, Pa. (Corp. M. Jan. '58) *P*

Hunter, Merril V., Owner, Hunter Eng. Co., 117½ McDonald St., Midland, Mich. (Jan. '58) *PD*

Ingle, Charles Ray, Supt., Water Plant, Red Key, Ind. (Jan. '58)

Jarvis, Herbert A., Sales Engr., Johns-Manville Sales Corp., 777 Thomas St., Seattle 9, Wash. (Jan. '58)

Johansen, Frederick A., Sales Engr., Johns-Manville, 101 Marietta St., Atlanta 3, Ga. (Jan. '58)

Johnson, A. G.; *see* City of Oakridge (Ore.)

Johnson, Arthur S., City Mgr., Greenville, Ill. (Jan. '58) *M*

Johnson, Herbert G., Cons. Engr., Johnson Eng. Co., 17 N. Drexel Ave., Havertown, Pa. (Jan. '58) *RD*

Johnson, John H.; *see* South Huntington (N.Y.) Water Dist.

Johnson, Raymond D., Admin. Engr., Comrs. Office, Dept. of Water & Sewers, 403 City Hall, Chicago, Ill. (Jan. '58) *M*

Kasting, John, Hoosier Water Co., Brownstown, Ind. (Jan. '58)

Kaup, Carl H., Owner, Water Conditioning Service Co., Box 441, Clinton, Okla. (Jan. '58) *PD*

Kenning, Robert S., Asst. City Mgr., 151 Martin St., Birmingham, Mich. (Jan. '58) *M*

Kinel, James O., Supt., Water Dept., Lyons, Ill (Jan. '58)

King, Ernest D., Field Supt., Santa Fe Irrigation Dist., Rancho Santa Fe, Calif. (Jan. '58) *PD*

King, Robert R., Cons. Engr., Robert R. King & Assocs., Preston at Sycamore, Sherman, Tex. (Jan. '58) *RPD*

Kirkwood, Willis Maynard, Mgr., Summerland County Water Dist., 2580 Lillie Ave., Summerland, Calif. (Jan. '58) *M*

Klein, Andrew M., City Engr., City Hall, Forest Grove, Ore. (Jan. '58) *MRPD*

Knight, Charles Henry, Jr., Civ. Engr., Portland Cement Assn., 816 W. 5th St., Los Angeles 17, Calif. (Jan. '58) *D*

Koger, W. C., Corrosion Engr., Cities Service Oil Co., Bartlesville, Okla. (Jan. '58) *PD*

Komo, Nicholas G., Salesman, Transite Pipe Div., Johns-Manville Sales Corp., 7912 Bonhomme Ave., St. Louis 5, Mo. (Jan. '58) *D*

Lamprey, Gerald H., Engr., Consumers Water Co., 95 Exchange St., Portland, Me. (Jan. '58) *P*

Langford, Robert E., Sales Repr., Diamond Alkali Co., 20 N. Wacker Dr., Chicago, Ill. (Jan. '58) *P*

LaVine, Russell J., Adv. Mgr., Highland Park News, 3811—6th Ave., Des Moines 13, Iowa (Jan. '58) *M*

Lee, Kong Hui, Civ. Engr., Bd. of Water Supply, Honolulu, Hawaii (Jan. '58) *RPD*

Lehrman, Russell E., Supt., Munic. Utilities, Kenyon, Minn. (Jan. '58) *D*

Linck, Charles J., Geologist, Layne-Northern Co., 2000 Turner St., Mich. (Jan. '58) *R*

Linehan, Kenneth J., Water Technician, Crown Zellerbach Corp., Antioch, Calif. (Jan. '58) *RPD*

Lybeck, Henry, Asst. City Engr., 13600 Oak Park Blvd., Oak Park, Mich. (Jan. '58)

Mabry, Frank L.; *see* City of Oswego (Kan.)

Magee, Dolph B., Filter Plant Supervisor, John Cunningham Filter Plant, Corpus Christi, Tex. (Jan. '58) *P*

Manning, David C., Supt., Water Dept., Spring Hill, Kan. (Jan. '58) *MRPD*

Maplethorpe, C. W., Jr., Doctor, Toledo, Iowa (Jan. '58) *MRPD*

Marine, I. Wendell, Ground-water Geologist, U.S. Geological Survey, 503 Federal Bldg., Salt Lake City, Utah (Jan. '58) *R*

Mark, Wayne, Sr., Supt. of Utilities, Water Works, Bainbridge, Ind. (Jan. '57)

Marshall, Elmer Louis, Field Engr., City of San Diego, San Diego, Calif. (Jan. '58) *D*

Martin, Charles Robert, Engr., Floyd G. Browne & Assocs., 123 W. Church St., Marion, Ohio (Jan. '58)

McCartha, Harry C., Jr., Vice-Pres., Sentell Supply Co., Inc., 250 N.E. 72nd St., Miami, Fla. (Jan. '58) *M*

McClintock, Richard Alan, Gen. Foreman of Services, Water Dept., Wichita, Kan. (Jan. '58) *D*

McCormick, Robert K., Sr. Public Health Engr., State Dept. of Health, 1523 Smith Tower, Seattle, Wash. (Jan. '58) *RP*

McPhee, Donald A., Foreman, Water Dept., 420 N. Pearl St., Ellensburg, Wash. (Jan. '58) *D*

McRea, Robert Bruce, Asst. Chief Engr., Bd. of Water Comrs., Box 600, Denver, Colo. (Jan. '58)

Menominee Bd. of Public Works, Clarence E. Young, Supt., 711—1st St., Menominee, Mich. (Munic. Sv. Sub. Jan. '58) *MRPD*

Miller, Jack P.; *see* Hummelstown Water Supply Co.

Miller, Raymond G., Owner, Kenmore Water System, Kenmore, Wash. (Jan. '58) *MD*

Mirabito, Thomas F., Owner, U.S. Soft Water Service, 724A Francisco Blvd., San Rafael, Calif. (Jan. '58) *P*

Mitchell Water Works, Sanford E. Wade, Mgr., 7th & Brook St., Mitchell, Ind. (Corp. M. Jan. '58) *MRPD*

Mogle, W. S.; *see* Dallas (Tex.) Waterworks

Moore, Kenneth E., Partner, Gil Moore & Co., 310 N. Normandie Ave., Los Angeles 4, Calif. (Jan. '58) *P*

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Moore, Roy T., Supt., Walnut Park Mutual Water Co., 2460 E. Florence Ave., Huntington Park, Calif. (Jan. '58) *MD*

Morris, G. T., Director of Public Utilities, Box 3466, Odessa, Tex. (Jan. '58)

Moss, J. L., Supt., Light & Water Dept., Homer, La. (Jan. '58) *M*

Murray, John P., 383 Adams St., Oakland, Calif. (Apr. '58)

Muschell, James Edward, City Engr., Cheboygan, Mich. (Jan. '58) *RPD*

Muss, David L., Asst. Prof. of Civ. Eng., City College of New York, New York, N.Y. (Jan. '58) *MRPD*

Muzio, Andrew H., Engr., R. D. Cole Mfg. Co., Newnan, Ga. (Jan. '58) *MD*

Nesbit, Noye H., Supt. of Filtration Plant, Gwinnett County Water System, Duluth, Ga. (Jan. '58) *P*

Nichols, Charles T., Water Supt., Borough of Rockaway, Municipal Bldg., Rockaway, N.J. (Jan. '58) *MD*

Niles, Charles Fernald, Jr., Engr., Henry B. Steeg & Assocs., Inc., 338 N. Illinois St., Indianapolis, Ind. (Jan. '58) *MRPD*

North Perry Avenue Water Dist., Harley Van Sickle, Chairman, 2921 Perry Ave., Bremerton, Wash. (Munic. Sv. Sub. Jan. '58) *MRPD*

Oakridge, City of, A. G. Johnson, Water Supt., Oakridge, Ore. (Munic. Sv. Sub. Jan. '58)

O'Bryant, Bill, Design Engr., Water Works, 301 Munic. Bldg., Dallas, Tex. (Jan. '58) *RD*

Olbert, Richard Powell, Civ. Engr., John A. Carollo, 3308 N. 3rd St., Phoenix, Ariz. (Jan. '58) *RPD*

Openshaw, A. B., Jr., Sales Engr., Henry Pratt Co., 2222 S. Halsted St., Chicago 8, Ill. (Jan. '58) *P*

Orr, Edward Alexander, Asst. Supt., Water Dept., Duke Power Co., Anderson, S.C. (Jan. '58)

Oswego, City of, Frank L. Mabry, Water Plant Supt., Box 342, Oswego, Kan. (Corp. M. Jan. '58) *MP*

Palecek, Francis Joseph, Asst. Supt., Water Treatment Plant, Holland, Mich. (Jan. '58) *MPD*

Parchment, City of, Sam Pool, Supt. of Water & Sewer Dept., Parchment, Mich. (Corp. M. Jan. '58) *PD*

Park, Robert Joseph, Pipe Salesman, The Keasbey & Mattison Co., Ambler, Pa. (Jan. '58) *D*

Perkins, Francis D., Repr., R. D. Wood Co., Box 111, Fayetteville, N.Y. (Jan. '58)

Peters, Bernard W., Supervisor of Water Meter Div., Water & Sewer Dept., 555 Lincoln St., Evanston, Ill. (Jan. '58) *M*

Peterson, Roy H., Jr., Cons. Engr., Alvord, Burdick & Howson, 20 N. Wacker Dr., Chicago, Ill. (Jan. '58) *P*

Pierce, William H., Student, Iowa State College, Ames, Iowa (Jr. M. Jan. '58) *P*

Pierson, Thomas W., Water Plant Operator, Water Dept., 609—29th St., Vienna, W.Va. (Jan. '58)

Pirkle, James Marshall, Water Supt., McCamey, Tex. (Jan. '58)

Pond, John, Research Assoc., The League of Kansas Municipalities, 512 Capitol Federal Bldg., Topeka, Kan. (Jan. '58) *M*

Pool, Sam; *see* City of Parchment (Mich.)

Presecan, Nicholas E.; *see* Twentynine Palms (Calif.) County Water Dist.

Prusan, Louis, Prin. Accountant, Water Dept., 323 County-City Bldg., Seattle 4, Wash. (Jan. '58) *M*

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Purves, Archibald Henry Blair, Pres., Purves Indus. Sales, 19 Belmont Rd., Halifax, N.S. (Jan. '58)

Ralston Purina Co., Herbert C. Schaefer, Mgr. of Chem. Labs., 835 S. 8th St., St. Louis 2, Mo. (Corp. M. Jan. '58) *P*

Ranquette, William S., Mgr., Electrical & Water Dept., Kaukauna, Wis. (Jan. '58) *MRD*

Reames, James P., Asst. Water Distr. Supervisor, Distr. Div., Water Works, 2861 Municipal St., Dallas, Tex. (Jan. '58) *D*

Robotti, John S., Plumbing, Heating, Electrical Contractor, Box 211, Rocky Hill, N.J. (Jan. '58) *MPD*

Rockwood Water Dist., Paul Stenzel, Chairman, 18302 S.E. Stark St., Portland 16, Ore. (Munic. Sv. Sub. Jan. '58) *MD*

Romano, James Anthony, Head, Dam Sec., Gannett, Fleming, Corddry & Carpenter, Inc., 600 N. 2nd St., Harrisburg, Pa. (Jan. '58) *MRPD*

Rosapepe, Joseph S., Burson-Marsteller Assocs., Inc., 800—2nd Ave., New York 17, N.Y. (Jan. '58)

Ruppert, Fred E., Asst. Engr., John A. Carrolo, 3308 N. 3rd St., Phoenix, Ariz. (Jan. '58) *MRPD*

Sand Spring Munic. Water Bd., J. T. Courter, Supt., Sand Spring, Okla. (Munic. Sv. Sub. Apr. '58)

Schaefer, Herbert C.; *see* Ralston Purina Co.

Scheid, John Leslie, Asst. Mgr., Munic. Div., Graver Water Conditioning Co., 216 W. 14th St., New York 11, N.Y. (Jan. '58) *MRPD*

Schramm, Allan George, Sales Repr., James B. Clow & Sons Co., Inc., 201–299 N. Talman Ave., Chicago, Ill. (Jan. '58) *PD*

Sherburne, William L., City Engr., City Hall, Berlin, Wis. (Jan. '58) *MRPD*

Short, Donald Clive, Pres., Western Development Corp., Box 1249, Chadron, Neb. (Jan. '58) *RPD*

Shung, Sae Yung, Engr., Bureau of Public Works, Ministry of Home Affairs, Republic of Korea, 310–9 Shin Sul Dong Dong Dae Mun Ku, Seoul, Korea (Jan. '58) *P*

Simons, Charles, Supt. of Water, Village Hall, Phoenix, Ill. (Jan. '58) *M*

Smith, Albert A., Waterworks Div. Mgr., Verako Products, Inc., Box 604, Waukegan, Ill. (Jan. '58)

Snell, M. E., City Engr., 420 N. Pearl St., Ellensburg, Wash. (Jan. '58) *MD*

Snyder, Roy C., Supt., Water & Street Dept., Toppenish, Wash. (Jan. '58)

South Huntington Water Dist., John H. Johnson, Chairman, Bd. of Water Comrs., W. 13th St. & 5th Ave., S., Huntington Station, N.Y. (Munic. Sv. Sub. Jan. '58)

Stenzel, Paul; *see* Rockwood Water Dist.

Stilley, Sydney Hiram, Cons. Engr., Sydney H. Stilley & Assocs., 1649 Atlantic Blvd., Jacksonville, Fla. (Jan. '58) *MRPD*

Strom, Thomas Elmo, Maint. Supt., Gwinnett County Water System, Lawrenceville, Ga. (Jan. '58) *D*

Stroudsburg Munic. Authority, William A. Curnow, Mgr., Munic. Bldg., Stroudsburg, Pa. (Munic. Sv. Sub. Jan. '58)

Sunnes, Phillip H., Gen Mgr., Harper & Co., 195—4th St., San Bernardino, Calif. (Jan. '58) *MP*

Swem, Estel L., City Engr., 30 Gerald Ave., Highland Park, Mich. (Jan. '58)

Sylvan, Matthew D., Salesman, Mueller Co., 4910 Briar, Mission, Kan. (Apr. '58)

Taiera, Bernard Stanley, San. Engr., Div. of Water Purification, 3300 E. Cheltenham, Chicago, Ill. (Jan. '58) *P*

Tengonciang, Salustiano T., Jr., Graduate Student, Liggett Hall, Washington Univ., St. Louis 5, Mo. (Jr. M. Jan. '58) *MRPD*

Thompson, Ivan E., Sales Engr., Johns-Manville Sales Corp., 777 Thomas, Seattle, Wash. (Jan. '58) *D*

Thon, J. George, Chief Civ. Engr., Power & Indus. Div., Bechtel Corp., 101 California St., San Francisco, Calif. (Jan. '58) *RPD*

Teal, Richard J., Service Mgr., E. W. Smith Chem. Co., 15020 E. Proctor Ave., La Puente, Calif. (Jan. '58) *P*

Tomkinson, Philip K., Well Field Foreman, Water Prod. Dept., 823 E. Jefferson St., Phoenix, Ariz. (Jan. '58)

Topping, Charles G., Asst. Dist. Sales Mgr., Pipe Div., Johns-Manville Sales Corp., 270 Madison Ave., New York 16, N.Y. (Jan. '58) *MD*

Tortorolo, Mario J., Supt., Distr., Water Dept., 2747 Indiana St., Napa, Calif. (Jan. '58) *D*

Trapnell, Fred A., Supt. of Water Distr., Rte. 4, Box 4, North Palm Beach, Fla. (Jan. '58) *MRPD*

Troutman, Ray Kent, Area Mgr., Wallace & Tiernan, Inc., Belleville, N.J. (Jan. '58) *P*

Tuscumbia Water Dept., L. E. Hamlet, Mgr., 202 E. 6th St., Tuscumbia, Ala. (Munic. Sv. Sub. Jan. '58) *M*

Twentynine Palms County Water Dist., Nicholas E. Presecan, Gen. Mgr., 73482 Twentynine Palms Hwy., Twentynine Palms, Calif. (Corp. M. Jan. '58) *MRPD*

Vancil, David E., Supt. of Utilities, Munic. Water System, Sabetha, Kan. (Jan. '58) *M*

Van Guelpen, Robert, City Engr., City Hall, Santa Rosa, Calif. (Jan. '58) *M*

Van Sickle, Harley; *see* North Perry Avenue Water Dist.

Varney, Robert Harold, Supt., Camden & Rockland Water Co., 5 Lindsey St., Rockland, Me. (Jan. '58) *M*

Vaudrey, Calvin, Cons. Engr., J. T. Banner & Assocs., 1432—2nd St., Brookings, S.D. (Jan. '58) *RPD*

Victoria Dept. of Recreation & Conservation, Provincial Parks Branch, W. J. Forsythe, Victoria, B.C. (Corp. M. Jan. '58)

Vondrick, Arthur F., Utilities Engr., Dept. of Water & Sewers, 815 E. Jefferson, Phoenix, Ariz. (Jan. '58) *MPD*

Wade, Sanford E.; *see* Mitchell (Ind.) Water Works

Waggener, Chester L., Director of Public Works, City Hall Annex, Moses Lake, Wash. (Jan. '58) *MRD*

Walling, Frank C., Chief Oper., Water Supply System, 155 Broad St., Keyport, N.J. (Jan. '58) *MD*

Walter, LeeRoy H., Sales Repr., Dorr-Oliver, Inc., 4117 Broadway, Kansas City, Mo. (Jan. '58) *P*

Walther, Arnold T., Water Supt., Western Springs, Ill. (Jan. '58) *MP*

Warnicke, Earl R., Supt., Public Works, Des Plaines, Ill. (Jan. '58) *MRP*

Weeks, Carl C., Salesman, Flex-Rod Pipe Tool Co., 351 W. Jefferson, Dallas 8, Tex. (Jan. '58) *D*

Willhite, Clarence A., Water Plant Oper., Post Engrs., Fort Richardson, Alaska (Jan. '58) *MRP*

Williams, Harold E., Sales Engr., American Cast Iron Pipe Co., 38 S. Dearborn St., Chicago 3, Ill. (Jan. '58)

Williams, Wesley R., Sales Engr., Dorr-Oliver, Inc., 900 Peachtree St., N.E., Atlanta, Ga. (Jan. '58)

Williams, Willmer Walter, Supt., Water Plant, Eau Gallie, Fla. (Jan. '58) *MRP*

Wortman, Charles Edwin, Operator, Pumping Station, West Lafayette Water Co., 117 Northwestern Ave., West Lafayette, Ind. (Jan. '58) *PD*

Wright, Bern, Exec. Secy., State Water Com., 17094 Washington St., E., Charleston, W. Va. (Jan. '58) *RP*

Wright, David Lee, Sales Administrator, Badger Meter Mfg. Co., 4545 W. Brown Deer Rd., Milwaukee, Wis. (Jan. '58) *M*

Wynn, Harold L., Jr., Engr., Chenango Corp., Box 72, Baldwinsville, N.Y. (Jan. '58) *D*

Young, Clarence E.; *see* Menominee (Mich.) Bd. of Public Works

Zimmer, Walter E., Secy.-Treas., Wolvering Eng. Co., Mason, Mich. (Jan. '58) *MRPD*

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Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.

Clarifiers:
American Well Works
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Coagulant Aids:
Hagan Chemicals & Controls, Inc.

Condensers:
Alco Products, Inc.
Allis-Chalmers Mfg. Co.
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Foxboro Co.
General Filter Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Tennessee Corp.

Corrosion Control:
Alco Products, Inc.
Calgon Co.
Industrial Chemicals, Inc.
Philadelphia Quartz Co.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.

Diaphragms, Pump:
Dorr-Oliver Inc.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Professional Services)

Feedwater Treatment:
Allis-Chalmers Mfg. Co.
Calgon Co.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Industrial Chemicals, Inc.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Carborundum Co.
Dicalite Div.
General Filter Co.
Infilco Inc.
Johns-Manville Corp.
Northern Gravel Co.
Permutit Co.
Stuart Corp.

Filters, incl. Feedwater:
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chain Belt Co.
Cochrane Corp.
Etablissements Degremont
Filtration Equipment Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Permutit Co.
Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
Alco Products, Inc.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:
American Agricultural Chemical Co.
Tennessee Corp.

Fluoride Feeders:
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

Gages, Loss of Head, Pressure of Vacuum, Rate of Flow, Sand Expansion:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Foxboro Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Worthington Corp.

Glass Standards—Colorimetric Analysis Equipment:
Klett Mfg. Co.
Wallace & Tiernan Inc.

Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.

Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Hypochlorite; see Calcium Hypochlorite; Sodium Hypochlorite

Ion Exchange Materials:
Allis-Chalmers Mfg. Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.

Iron, Pig:
Woodward Iron Co.

Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Permutit Co.
Wallace & Tiernan Inc.

Magnetic Dipping Needles:
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.

Ford Meter Box Co.
Gamon Meter Div., Worthington Corp.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Foster Eng. Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Well Machinery & Supply Co.

Meter Repair Parts:
Meter Specialty Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
Infilco Inc.
F. B. Leopold Co.

Paints:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe, Steel:
Alco Products, Inc.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipe Cleaning Services:
National Water Main Cleaning Co.

Pipe Coatings and Linings:
American Cast Iron Pipe Co.
Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Layne & Bowler Pump Co.

Pumps, Diaphragm:
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Layne & Bowler Pump Co.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.
Sparling Meter Co.

Sand Expansion Gages; see Gages

Sleeves: see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Chloride:
International Salt Co., Inc.

Sodium Fluoride:
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon Co.

Sodium Hypochlorite:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
Tennessee Corp.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
Cochrane Corp.
General Filter Co.
Industrial Chemicals, Inc.
Infilco Inc.
International Salt Co., Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Infilco Inc.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Water Softening Plants: see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

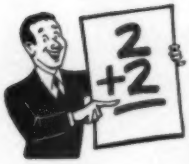
Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.

The solution to this problem is always the same . . . but

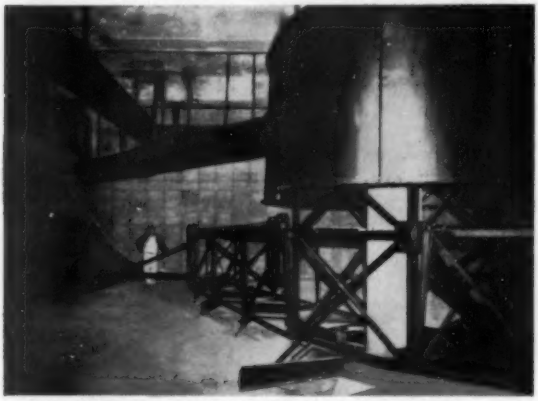
Water Treatment Problems are different

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa



St. Cloud, Minnesota

Dorr Squarex Clarifiers Installed Under City Park...



Underneath Hester Park are two of these large (55' sq.) Dorr Squarex Clarifiers.

In 1953, the City of St. Cloud, recognizing the obsolescence and inadequacy of their original water filtration plant, retained the services of Consoer, Townsend and Associates to design modern water treatment facilities to treat and soften Mississippi River water and which would be suitably attractive, as the plant was located adjacent to the city's Hester Park.

On October 31, 1957, the new St. Cloud Water Treatment Plant, situated on the Mississippi River, was officially opened. Over fifty percent of the plant's facilities are located under Hester Park; granite-faced administration and control buildings constitute the plant's exterior

Playing an important role in St. Cloud's new facilities are two Special SZ-7, Dorr Squarex Clarifiers, each 55 ft. sq. x 15 ft. s.w.d. These two Squarex Clarifiers, equipped with concrete center columns, are installed in underground clarifying basins, each of which will hold a half-million gallons. The Dorr Squarexes were designed for a population equivalent of 50,000 and average design flows of 9 MGD.

Squarex, T.M., Reg. U. S. Pat. Off.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

St. Cloud's Administration & Control Building.

LEADITE

Trade Mark Registered U. S. Pat. Office

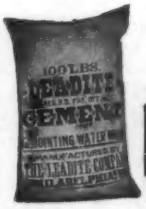
Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%



THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking